AN INVESTIGATION OF THE DYNAMIC CHARACTERISTICS OF A TWO-GYRO COMPUTING SYSTEM FOR AERODYNAMIC LEAD PURSUIT COURSES

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Professor Joseph S. Newell
Secretary of the Faculty
Massachusetts Institute of Technology
Cambridge, Massachusetts

Dear Sir:

In accordance with the requirements for the degree of Master of Science, we herewith respectfully submit a thesis entitled "An Investigation of the Dynamic Characteristics of A Two-Gyro Computing System for Aerodynamic-Lead Pursuit Courses."

Sincerely yours,

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TABLE OF CONTENTS

INTRODUCTION

In the field of fire control, one of the most important problems confronting the designer is that of furnishing an accurate solution for the control of fire from fixed guns carried by an airplane flying along a curved path. In order to overcome this problem, sights of various types have been or are being designed. The type considered in this thesis is a gyro-computing, disturbed-line-of-sight type of gunsight. With the computer case of the gunsight being rigidly mounted to the structure of the attacking airplane, the foremost problem is to determine the effect of any possible motion of the computer case on the indicated sight prediction angle determined by the computer.

An A-1 sight installed in an F7F type airplane will be used in this project for the purpose of investigating the overall dynamic characteristics of a two-gyro computing system for aerodynamic-lead pursuit courses. Some work of this nature has previously been done by the Army Air Forces with a P-38 type airplane at Eglin Field, Florida, and by the M.I.T. Instrumentation Laboratory using an A-26 airplane at the Bedford Airport, Bedford, Massachusetts.

It is hoped that information obtained by this thesis will be of value in the development program of such a computing system, as well as to provide information for assessment and evaluation to the Aviation Armament branches of the Army and Navy.

In order to analyse the motion of an aircraft which is flying along a curved path, this motion is resolved into three components about mutually perpendicular axes, i.e., deflection, elevation, and cross roll.

Since gyroscopic elements respond to angular velocity inputs with respect to inertial space, they are used in computer mechanisms to determine the deflection and elevation predicted lead angles by proper orientation of their spin axes with respect to the axes of motion of the computer case. Originally it was intended that a three-gyro (each with a single degree of freedom) computing gunsight be used to investigate the problem. This sight had separate computer sections for motions about the elevation, deflection, and cross roll axes. The cross roll computer resolved motion about its axis into proper inputs to the elevation and deflection computer systems so that the roll or bank of the airplane would introduce substantially no error to the predicted lead angles. Unfortunately, after this sight and the necessary assessment equipment had been installed and boresighted in an F6F type fighter aircraft, the plane crashed at sea on its initial mission. No equipment or experimental data was salvaged. However, since the calibration data was exceptionally good, indicating that the sight quite probably would have been an improvement over present designs, this data has been included in Appendix I of this thesis so that it may be used as a criterion in the construction and calibration of another three-gyro computing gunsight.

Because the sight which was lost could not be replaced in time to complete the original thesis, a production model of the A-1 computing gunsight was used as a substitute. This type of sight has two computing sections, elevation and deflection, each utilizing a single-degree-of-freedom gyro. There is no cross roll computing section. In order to compensate for errors which would be introduced by motion about the cross-

roll axis of the airplane, the deflection gyro input axis is inclined ten degrees from the deflection axis of the airplane. This inclination reduces the input effect of the deflection component of the controlled line angular velocity from $W_{(CL)d}$ to $W_{(CL)d} \cos 10^{\circ}$.[x] At the same time the inclination provides a component of the angular velocity of the computer case about the controlled line as an input to the deflection computing system equal in magnitude to $W_{(Ca)c} \sin 10^{\circ}$. This input moves the tracking index in a direction to neutralize errors which are produced by motion about the cross-roll axis.

The elevation prediction computer receives as inputs the effective acceleration component parallel to the deflection axis, the angular velocity of the computer case about the elevation input axis, and the elevation sensitivity current. Its output is an angular displacement of its computer shaft which is the input to the elevation indicating system.[+]

The deflection prediction computer receives as inputs the angular velocity of the computer case about the deflection input axis, and the deflection sensitivity current. The output of the deflection computing system is an angular displacement of its computer shaft which is the input to the deflection indicating system.

The elastic restraint stiffness motors on the computer shafts are provided with sensitivity currents from the sensitivity control system. The sensitivity control system normally has inputs of present range and

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[x]See Symbols and Definitions

[+]Detailed Theory and Computations for the A-1 Sight for the Control of Gunfire from Fixed Guns, Rocketfire, and Bombing from Aircraft, Vols. I and II, by the Instrumentation Laboratory, M.I.T.

atmospheric pressure. However, since this investigation was concerned with the dynamic behavior of the prediction angle at specific sensitivities, a switch was installed to allow the pilot to select sensitivities of 2, 4, and 6 seconds. The sensitivity varies inversely as the elastic restraint, an infinite restraint giving a sensitivity of zero.

This thesis is concerned with the control of gunfire from fixed guns in an airplane which flies a pursuit course or curved path. Since the A-1 sight is of the disturbed-line-of-sight type, indirect tracking control is used. The sight moves the tracking index "backward'' from the controlled line by the amount of the predicted lead angle it has computed. Normally, when tracking is started, the sight is caged until the proper angular velocity inputs are received; then it is uncaged. If the controlled line could be moved forward instantaneously by the amount of the correct indicated prediction angle when the sight is uncaged, an instantaneous solution could be obtained. This is obviously impossible because a finite time is required for the tracking line to move to the correct position. This type of disturbed sight has exponential response characteristics so that theoretically it would require an infinite amount of time for a perfect solution to be obtained. For practical purposes, when 95 percent of the initial error has been eliminated, it is considered that a satisfactory solution has been attained. The time interval required is called the <u>solution time</u>. The solution time depends upon the dynamic response characteristics of the computer mechanisms, and is one of the important elements to be investigated in this thesis.

In order to analyze the sight's performance so that it may be compared among sights, the stability number of the sight must be known. The stability number, SN, is defined by the following equation:

$$SN = \frac{(CT)_m}{S_{p(WP)}} - 1 \qquad (1)$$ [♦ x]

Stability number is directly proportional to the gyro wheel speed and the viscosity of the fluid in the computer shaft damper. Since the gyros are run by induction motors and their speed is constant (as determined by the speed of the inverter), the damping is the only variable which may be changed. The damping was adjusted to give a stability number of 0.2. This setting was made by positioning the rheostat in the damper heater control circuit. Finally, the mechanism characteristic time is defined as the ratio of the damping coefficient to the elastic restraint on the computer shaft;

$$(CT)_m = \frac{C_s}{K_e} \qquad (2)$$

Since the angular velocity-prediction angle sensitivity is also inversely proportional to the elastic restraint,

$$S_{p(WP)} = \frac{KS_{i(AP)}}{K_e} \qquad (3)$$

it follows that the stability number is independent of elastic restraint, and therefore of range, since range adjustments control the elastic restraint. Therefore, the stability number is constant, dependent only upon the calibration adjustment of the computer damping. It has also been determined that the tracking ratio is related to stability number as follows.

$$TR = \frac{SN}{SN + 1} \qquad (4)$$

and that the solution time is related to stability number by the formula

$$ST = 3 \left[\frac{TR}{1 - TR} \right] S_{p(WP)} \qquad (5)$$

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[x] See Symbols and Definitions for notation of all equations.

[♦] Reference listed page 3 for equations 1, 2, 3, 4, and 5.

For the rigorous treatment of this fire control problem, assuming roll stabilization and motion restricted to the horizontal plane, typical solutions of the following equations have been obtained from the Rockefeller Differential Analyzer of the Massachusetts Institute of Technology.[*] It can be seen from the equations that angle of attack and target angle vary throughout the problem. $S_{p(WP)}$ is maintained constant.

$$\dot{R}_T = V_T \cos A_T - V_A \cos (P_{sh} - \alpha_h) \qquad \dagger\ (6)$$

$$\dot{\alpha}_h = \dot{P}_{sh} - \dot{A}_T - \frac{\alpha_h}{kV_A}, \text{ where } k = \left[\frac{W_A/S}{P_{dyn}} \frac{1}{dC_L/d\alpha} \right] \frac{1}{g} \qquad \dagger\ (7)$$

$$\dot{P}_{sh} = - \frac{P_{sh}}{S_{p(WP)}(SN)} - \frac{\dot{A}_T}{SN} \qquad \dagger\ (8)$$

$$\dot{A}_T = \frac{V_A}{R} \sin [P_{sh} - \alpha_h] - \frac{V_T}{R} \sin A_T \qquad \dagger\ (9)$$

For the experimental as well as for the exact solution of the problem, certain limitations imposed by operational aspects should be considered. With the many parameters which can be varied, it is necessary to limit the scope of the problem to one type of pursuit curve. For this project it was decided to use only one type of run, restricting it to the horizontal plane, with an initial target angle between 90 and 120 degrees. The ratio of speeds of the attacking and target planes was about two. The angle of attack, although not zero in the actual problem, is assumed to be initially zero and is not considered throughout the solution of the experimental

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[*] See Appendix II, Figure 1, plots of these solutions and for defining and initial conditions.

[†] See thesis entitled "An Investigation of the Performance Characteristics of a Computing System for Air-to-Air Interception," submitted August, 1947, by Lt. Comdrs. Rofe, Bruce, Gams, and Craig, USN, for development of these equations.

problem, although it is taken into account by the A-1 sight. The sensitivities selected were 2, 4, and 6 seconds; close, medium, and long ranges.

CHAPTER I

APPARATUS

I. AIRPLANES

An F7F-2N airplane (night fighter), assigned to the Naval Air Test Center, Patuxent River, Maryland, was used for this project. This plane, Bureau Number 80294, arrived at Squantum Naval Air Station on July 22, 1947, for the purpose of calibration of a previously installed A-1 universal type gunsight by the Instrumentation Laboratory of the Massachusetts Institute of Technology. The gunsight was installed in the airplane by the Naval Air Modification Unit, Johnsville, Pennsylvania. Permission was granted for the use of the F7F airplane, upon completion of laboratory calibration of the gunsight, in obtaining experimental data for this project.

The target airplane is an SNJ-4 type which is used extensively by the Army and Navy for training purposes. This airplane is one of the normal complement of planes used for training flights at Squantum Naval Air Station.

The original apparatus for this project consisted of an F6F type airplane in which was installed a three gyro version of the A-1 computing gunsight, designed and built by the Instrumentation Laboratory at M.I.T. After calibration and installation of the gunsight in the airplane, a mechanical failure in the engine in the vicinity of Graves Light, Boston Harbor, resulted in a water landing and complete loss of plane and equipment.[x] At the time of the accident, flight test calibration was being conducted in order to obtain angle of attack data for various airspeeds as well as making a preliminary check for proper sight operation.

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[x] See Appendix I for details of calibration and installation of this gunsight.

Unfortunately no actual flight test data was obtained.

II. GUNSIGHT

A production model A-1 computing gunsight, built by the A.C. Spark Plug Company, was used in this investigation. This sight, and its operation, are described elsewhere in this thesis.

Boresighting of the gunsight was accomplished by use of normal boresight equipment furnished by the manufacturer of the plane. Lifting jacks for leveling the plane and a portable screen were provided by facilities at the Squantum Naval Air Station.

III. CAMERAS AND ASSESSMENT

Two GSAP Bell and Howell cameras were used in obtaining tracking and flight data. The cameras were magazine loaded, each magazine containing 50 feet of 16 mm. film. One camera was mounted in the radar operator's position (rear seat of the F7F), in order to photograph the airspeed meter, altimeter, accelerometer, sweepsecond clock, and the bank indicator. The other camera was mounted on the sight head to photograph the sight reticle, camera reference marker, and the target plane.[x]

Satisfactory photography was obtained with negative panchromatic film, speed 25, using stop f.11, and a shutter speed of 1/50th second. All film was processed by the photographic personnel at the Naval Air Station, Squantum, Massachusetts.

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[x]For detailed camera circuitry and mounting, see Appendix I, Sec. 6

Bell and Howell motion picture projectors were used for the film assessment. The projectors were adjustable with respect to a fixed calibration screen. By means of 100 mil calibration marks on one set of exposed film, obtained while boresighting, the screen calibration scales were made identical with that on the film by proper adjustment of the projector. With this adjustment made, distances on the calibration screen could be measured directly in mils.

CHAPTER II

FLIGHT PROCEDURE

For the purposes of this report, a mission is defined as a flight during which sufficient runs were made to completely expose fifty feet of assessment camera film (approximately six runs). Missions flown in the course of this investigation included two familiarization and test flights, and four missions on which data was taken.

The two familiarization and test missions were made in order to check the proper operation of the assessment cameras and to familiarize the pilot of the attacking airplane in the operation of the gunsight and in the type of runs desired.

Missions for record were made as follows:

a. The attacking and target airplanes joined up at an altitude which gave freedom for maneuvering and proper lighting for photography.

b. The target airplane took up a heading and flew at 100 knots indicated, at a constant altitude.

c. The attacking airplane maneuvered into a position from which it could make a run which conformed as closely as possible to the standard runs desired. The standard run was one which was to be made on the same horizontal plane as the target airplane, initial target angle of ninety degrees, initial range of two thousand yards, and an airspeed of 200 knots indicated.

At the beginning of a run the attacking plane's pilot caged the sight's reticle, started the cameras, then uncaged the sight reticle after first maneuvering his airplane so that the reticle was "on" the target aircraft. The pilot then endeavored to track the target in as close as possible before breaking off the run. After the run was completed, the cameras were stopped and the attacking airplane took position for another run.

CHAPTER III

DATA OBTAINED

In the assessment of the films of the runs made, every fourth frame was analyzed. This represented conditions at approximately each quarter second throughout the tracking run.

At each frame read, the location of the reticle in elevation and deflection on the calibrated screen was recorded in mils. By energizing the flagging circuit in the camera before the gyro was uncaged, the caged position of the reticle was obtained (determined by the appearance of the flag in the film). The difference between this position and succeeding positions of the reticle gave the sight prediction angles in elevation and deflection. The difference between reticle and target positions at any particular time was the inaccuracy of the tracking line in elevation and deflection. No attempt was made to separate the inaccuracy into error and uncertainty. An inaccuracy in elevation was considered positive if the reticle was below the target, and an inaccuracy in deflection was considered positive if the reticle was to the left of the target. With the assessing scales used, the numbers increased from right to left and from the top down.

For frames from the rear camera recording the instrument panel, frames corresponding to those of the front camera were analyzed, and the following were recorded: airspeed, altitude, accelerations, and elapsed time. Slip or skid were observed. From the recorded data, the prediction angles and tracking inaccuracies were calculated and plotted in Appendix II.

In order to provide a basis for comparison of the experimental data with the theoretical data, the mathematical solutions obtained from the Rockefeller Differential Analyzer were also plotted in Appendix II.

CHAPTER IV

RESULTS

Figure 1 shows plots of the predicted lead angle versus time data obtained from differential analyzer solutions of the flight path equations approximating those conditions which existed for the actual tracking runs. Figures 2 through 15 are plots of similar data experimentally obtained from the tracking runs. Figure 16 shows two plots; curves of experimental and theoretical solution times versus static sensitivity of the sight computer, and a curve of tracking line inaccuracy versus static sensitivity of the sight computer.

The theoretical solution of Ps versus time gives a smooth curve starting from the zero or caged position of the sight reticle, and rising exponentially as the sight generates the proper initial lead angle. The slope of this curve decreases after the initial solution is reached. As the range decreases and the attacking plane closes in on a tail chase of the target plane, the curve then steepens sharply, indicating increasingly larger required leads. This plot of lead angle versus time does not represent an actual aerodynamic lead pursuit course gunfire problem for the following important reason. In an actual problem the static sensitivity is a variable. It is a function of present range, or of time of flight of the projectile from the attacking plane to the target. As the range decreases the time of flight decreases, which tends to make constant the amount of lead necessary in the final stages of the run. As previously explained in this report, the static sensitivity was held constant for a particular run in order to simplify the investigation. Holding the static sensitivity constant during the run actually made it more difficult for the

pilot to track perfectly and consequently increased the magnitude of the dynamic errors present in the latter stages of each run.

Inspection of the experimentally obtained curves of predicted lead angle versus time reveal the gunsight's solution of the fire control problem to be basically the same as the theoretical solution. The exponential part of the experimental curves can be clearly delineated in each case. After the sight has generated the initial predicted lead angle, the curves of predicted lead follow, in general, a sinusoidal motion throughout the remainder of the run.

One of the conditions imposed on the pilot of the attacking airplane was that he should track the target with the sight reticle in the caged position for about two seconds prior to uncaging the sight. This imposition caused a marked divergence in the shapes of the curves of P_{se} and P_{sd} versus time. An inspection of the experimental curves of any run shows that, while the P_{sd} curve has a generally positive slope throughout the run, the P_{se} curve has an initial positive slope that changes to a large negative one just after the initial solution is reached. In about the last third of the run the slope of P_{se} curve resumes a generally positive value. The magnitude of P_{se}, being measured with respect to the longitudinal axis of the attacking airplane, is a function of the angle of bank at any instant. For example, with the pursuit curve kept in the horizontal plane of the target as it was in this investigation, if the attacking airplane were to bank vertically during a run, all the lead would appear as an elevation lead angle.

The explanation of the behavior of the P_{se} curve is that when the pilot uncages initially, and the sight reticle moves away toward a solution,

he has to fly his airplane so that the controlled line is directed out ahead of the target in order to keep the reticle on the target. In making this maneuver, the airplane must be sharply banked. However, as soon as the predicted lead angle becomes relatively stable, the pilot must "shallow out" the flight path slightly. In doing so he reduces the bank angle and hence the magnitude of the P_{se}. When the predicted lead angle begins to increase rapidly near the end of the run, the pilot has to increase the angle of bank which results in P_{se} increasing positively at about the same rate that P_{sd} increases.

Since tracking inaccuracies were present in all the experimental runs a plot of their average magnitudes versus sensitivity setting has been made on Figure 16. The plot shows that the inaccuracy increases as sensitivity (and therefore predicted lead angle) increases. This condition probably exists because it is more difficult for the pilot to keep the reticle in view when the lead angle is large. Furthermore, the tracking line motion (reticle motion) is more loosely coupled to the controlled line motion for large predicted lead angles.

The average magnitude of the tracking inaccuracies appearing during the runs was larger than expected. However, as it was pointed out earlier in this discussion, the static sensitivity was held constant during the run and this acts to increase the tracking difficulties. Furthermore, the pilot of the attacking plane had little previous experience with this type of sighting system. Experimental tests have been made using the disturbed type gunsight to track while in shallow dives on a fixed ground target. Inaccuracies were found to be in the order of from one to two mils.[x]

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[x] See Thesis entitled "Experimental Determination of Tracking Inaccuracies of Fixed and Disturbed Gunsights in Fixed Gun Fighter Aircraft, submitted August 24, 1946, to MIT by Lt.Cmdrs. V.P.dePoix, J.J.Hinman, H.F.Lloyd, R.W.Rawson, USN.

Theoretically the time required for this gunsight to generate a solution, after being uncaged, is approximately six tenths of its static sensitivity in seconds. This relation is verified on the theoretical curves plotted on Figure 1. From the experimental results it was estimated that the solution time was approximately twice the theoretical values. Roughness of the angular velocity inputs to the sight computer due to the pilot's inability to track perfectly was probably the cause of this increase in solution time. While this increase appears to be undesirably large, the experimental curves definitely show the sight had generated a proper predicted lead angle even for the runs with the highest sensitivity setting before the runs were half completed.

A simple change in the pilot's procedure of making a tracking run would materially reduce the solution time for that run. This change would require the pilot to anticipate the approximate lead prior to uncaging his sight at the beginning of a run and to position his airplane accordingly. It is also considered this procedure would reduce the tracking inaccuracies throughout the run by eliminating the necessity of the pilot having to track the target during the transient part of the predicted lead solution.

No attempt has been made in this investigation to determine any errors that might enter the problem due to changes in angle of attack of the attacking airplane during the tracking run. These errors, if present, were probably small because a study of the data taken shows a maximum change of only one tenth "g" in the linear acceleration on the airplane during the course of this particular type run.

CHAPTER V

CONCLUSIONS

On the basis of the foregoing results, the following conclusions are presented:

1. The actual time required for a disturbed gunsight to generate a solution will always be greater than the theoretically determined time due to inaccuracies in tracking.
2. Tracking inaccuracies and sight solution time increase with the sight's static sensitivity.
3. Dynamic errors will be present in any tracking run due to the pilot's inability to track perfectly.
4. Under the conditions of this investigation the tracking inaccuracies and sight solution time could have been decreased if the attacking plane pilot had followed a procedure of anticipating the approximate required lead at the beginning of a run and had positioned his plane accordingly.

SYMBOLS AND DEFINITIONS

CL	Control line. Actual controlled line position which is usually parallel to the boresight line of the airplane.
LS	Line of sight to the target.
ST	Solution time.
SN	Stability number of sight.
TR	Tracking ratio
R_d	Deflection coordinate of the tracking index or reticle on the projection screen. Measured in mils.
R_e	Elevation coordinate of the tracking index or reticle on the projection screen. Measured in mils.
T_d	Deflection coordinate of the target on the projection screen. Measured in mils.
T_e	Elevation coordinate of the target on the projection screen. Measured in mils.
$P_{s(e \text{ or } d)}$	Elevation or deflection component of indicated prediction angle.
P_s	Indicated prediction angle, or output angle.
P_{sh}	Indicated prediction angle as measured in the horizontal plane.
$C_{c(e \text{ or } d)}$	Damping coefficient of elevation or deflection computer.
$k_{c(e \text{ or } d)}$	Spring constant of elastic restraint on elevation or deflection computer shaft.
H	Angular momentum of gyro rotor about spin axis.
R_T	Present range from attacking airplane to target.
α_h	Angle of attack of attacking airplane or missile with respect to the horizontal.
A_T	Target angle. Angle measured from present line of sight extended to the direction of motion of target.
V_T	Target velocity measured in knots.
V_A	Attacking airplane velocity measured in knots.

$W_{(CL)(e \text{ or } d)}$	Elevation or deflection component of angular velocity of controlled line.
$W_{(Ca)e}$	Angular velocity of computer case about controlled line.
$W_{i(e \text{ or } d)}$	Elevation or deflection component of angular velocity input to gyro element.
W_{ir}	Cross roll component of angular velocity input to gyro element (same as W_{CR} in Appendix I).
$(CT)_m$	Mechanism characteristic time.
$S_{p(WP)(e \text{ or } d)}$	Angular velocity-prediction angle sensitivity of elevation or deflection prediction system.
$S_{p(WP)CR(e \text{ or } d)}$	Angular velocity-prediction angle sensitivity of deflection or elevation prediction system due to cross roll.
$S_{p(W\dot{P})(e \text{ or } d)}$	Angular velocity-prediction angle rate sensitivity of elevation or deflection prediction system.
$S_{i(AP)(e \text{ or } d)}$	Sensitivity of elevation or deflection indicating system with computer shaft angle input and prediction angle output.
$A_{c(e \text{ or } d)}$	Elevation or deflection computer shaft angular displacement from reference position.
A_{cr}	Angular displacement of cross roll computer shaft.
$e_{(Ac)(e \text{ or } d)}$	Elevation or deflection pickoff voltage proportional to angular displacement of elevation or deflection computer shaft.
$i_{(Ac)(e \text{ or } d)}$	Cross roll pickoff excitation current proportional to elevation or deflection pickoff voltage.
i_{er}	Elastic restraint excitation current.
SPR	Sensitivity period ratio
$(I)TL_{(e \text{ or } d)}$	Inaccuracy in tracking line position.
$P_{(dyn)}$	Pressure output from pitot static head.
W_A/S	Wing loading of airplane.
$\frac{dC_L}{d\alpha}$	Slope of lift curve of airplane.

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APPENDIX I

CALIBRATION AND INSTALLATION PROCEDURE FOLLOWED IN THE ASSESSMENT OF A THREE GYRO LEAD COMPUTING SIGHT DESIGNED EXPRESSLY FOR TEST IN THE F6F NAVY FIGHTER AIRCRAFT

PREFACE

The calibration procedure and data contained herein constitute work done on a thesis which was concerned with an investigation of various properties of a gyroscopic lead computing sighting system, using the disturbed line of sight principle. Work on this thesis was terminated when the aircraft in which the equipment was installed crashed. However, since the sighting system performed so well that a similar system will be built in the near future, the procedure and data are published for reference.

The sight with its component parts was designed and manufactured by the Massachusetts Institute of Technology Instrumentation Laboratory for this thesis. Its design closely follows that of the A-1 sight developed by that laboratory for the Army Air Forces. Some of the modifications made on the A-1 sight for this investigation were:

1. The installation of a third gyro for the purpose of checking the effects of cross roll on the computing problem.
2. Components which correct for gravity drop and linear acceleration were omitted.
3. Air density correction unit was omitted.
4. Present range input was omitted.
5. Certain other components, required when the sight is to be used as a bomb or rocket sight, were omitted.

These modifications of the basic sight were made during its construction in order to simplify its manufacture. Since the object of the investigation of this type of lead computing sight was, in brief, to determine qualitatively its practicability as a sighting system and as an interception course computer, the exact solution of the air to air gunfire problem for a particular weapon was not attempted. Hence, such factors as 2, 3, 4, and 5 above were omitted.

LIST OF LABORATORY EQUIPMENT USED IN THE BENCH CALIBRATION OF THE SIGHT

1. Electrically driven, variable speed turntable.
2. Stop watch, scales, and mirror.
3. Ammeter for measurement of current in the sight's stiffness motors.
4. A suitably mounted spherical segment with deflection and elevation marks inscribed.
5. Mounting base for the computer case inclined 30 degrees to the horizontal for mounting the computer case on the turntable.
6. Oscillating table to provide sinusoidal motion to computer case.
7. 28 volt d-c supply.

LIST OF ILLUSTRATIONS

CALIBRATION AND INSTALLATION PROCEDURE FOLLOWED IN THE ASSESSMENT OF A THREE GYRO LEAD COMPUTING SIGHT DESIGNED EXPRESSLY FOR TEST IN THE F6F NAVY FIGHTER AIRCRAFT

I. ARRANGEMENT OF THE COMPONENT PARTS OF THE SIGHTING SYSTEM FOR LABORATORY CALIBRATION

The input signal to the computer case is an angular velocity of the airplane about the roll and pitch axes. To simulate these inputs, the computer case was rigidly attached to a wooden frame which in turn was mounted rigidly to an electrically driven, variable speed turntable. In order to obtain inputs about either the elevation or deflection axes without tipping the computer 90 degrees away from the vertical, the wooden frame was built so that the actual angle between the plane of rotation of the turntable and the elevation input axis was 30 degrees. Therefore, the actual input angular velocity was not that of the turntable, but the turntable angular rate multiplied by the sine of 30 degrees for the elevation unit, and by the cosine of 30 degrees for the deflection unit. In order to avoid confusion between the elevation and deflection systems when making angular measurements, the computer system not in use was made inoperative by deenergizing its gyro. In addition, the cross roll computer system's electrical connections to the sight head mirror servos were disconnected by means of a switch on the pilot's control box, except during the calibration of the cross roll system.

The sight head was clamped to a rigid stand in a position to permit the sight's tracking index to be reflected, by means of a mirror attached to the sight head's reflecting glass, onto the spherical segment having elevation and deflection scribe marks. It was necessary to

properly orient the spherical segment so that its scale of elevation and deflection marks actually denoted mils angular movement of the tracking index. The remaining sight components were located nearby so as to be easily accessible for adjustment.

II. CALIBRATION OF THE ELEVATION PREDICTION ANGLE COMPUTING SYSTEM

a. STATIC SENSITIVITY $S_{p(WP)e}$

The static sensitivity depends on the magnitude of current flow in the stiffness motors on the elevation, deflection, and cross roll computer shafts. In this sighting system, the sensitivity of both the elevation and deflection computers is controlled by means of a switch on the pilot's control box. This switch has ten detented positions for regulating the stiffness motor currents, and the purpose of this calibration was to adjust the current at each position to obtain a range of sensitivities from zero to five seconds, in ten approximately equal increments.

With the sight energized and in operating condition, but with the deflection gyro disconnected and the cross roll circuit turned off, the $S_{p(WP)e}$ was determined in the following manner.

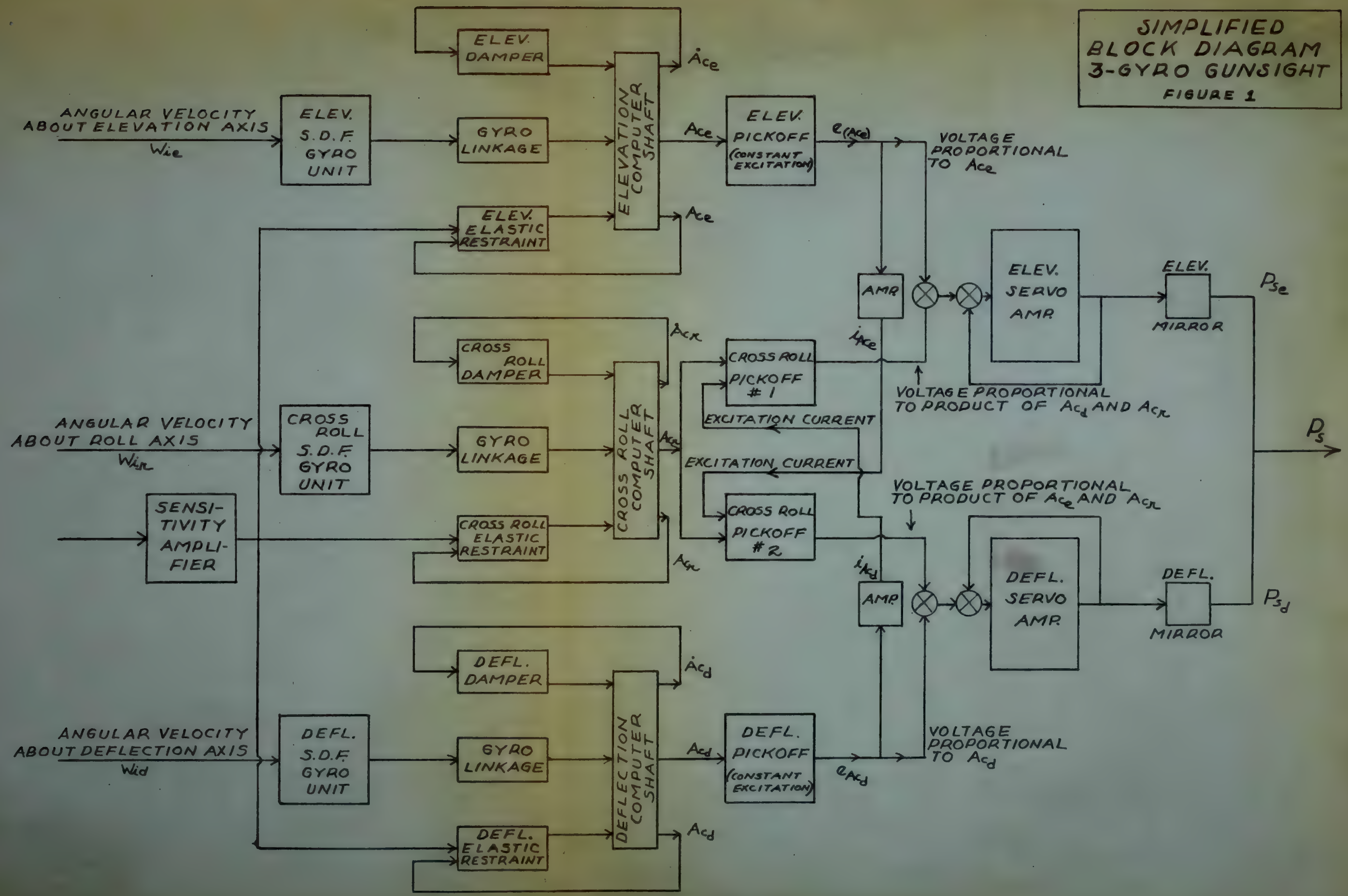
An angular velocity input was applied to the computer case and the elevation prediction angle generated on the spherical segment corresponding to this input was noted. Data was recorded for each run as follows: angular velocity input, elevation prediction angle, sensitivity setting, and stiffness motor current. Enough runs were made to cover adequately the range of elevation prediction angles from zero to plus and minus 250 mils.

A plot of prediction angle versus angular velocity input about the elevation axis for each sensitivity setting gave a series of points through which a straight line was drawn. The slopes of these lines are the $S_{p(WP)_e}$ values for the various sensitivity settings. Stiffness motor current was adjusted in each case until the proper slopes were obtained.

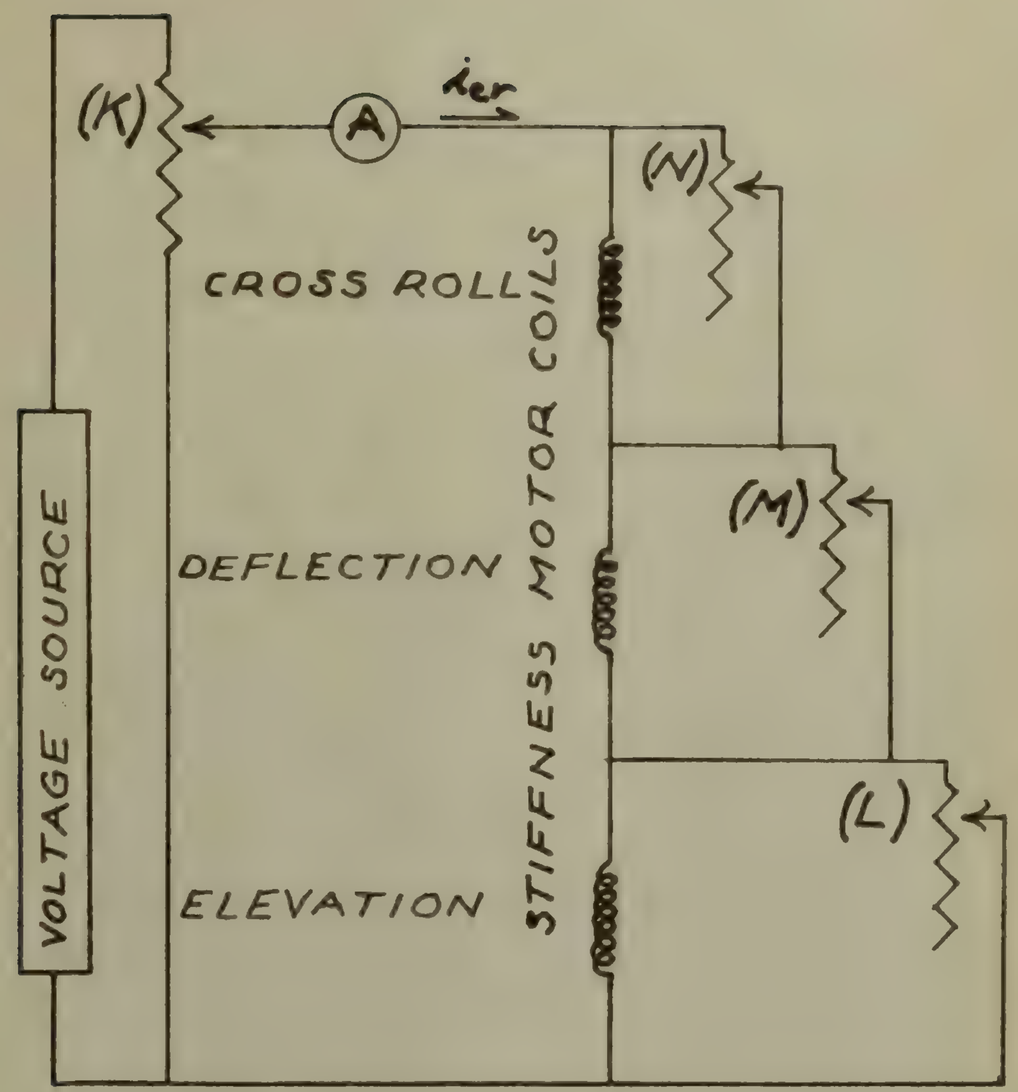
Adjustment of maximum sensitivity to a specified value was made by altering the amount of stiffness motor current through the elevation stiffness motor. In this calibration, sensitivity setting number 1 corresponded to a maximum sensitivity, and was adjusted to five seconds by means of a potentiometer in the elevation sensitivity control amplifier circuit marked "L" in Figure 2. The adjustment of the sensitivity current for any particular setting of the control switch affected the other sensitivities, and it was necessary to recheck all positions as changes were made. The final plot of prediction angle versus input angular velocity appears in Figure 3, and the slopes of these lines were then taken and plotted against sensitivity setting, and are shown in Figure 4.

b. STABILITY NUMBER (SN)

The next step in the calibration procedure was to adjust the damper fluid temperature to yield a stability number of 0.2 for the elevation computing system. Stability number is a function of gyro wheel speed and of damping on the computer shaft. The gyros were run by induction motors at a constant speed determined by the speed of the inverter. Thus, with constant gyro wheel speed, stability number



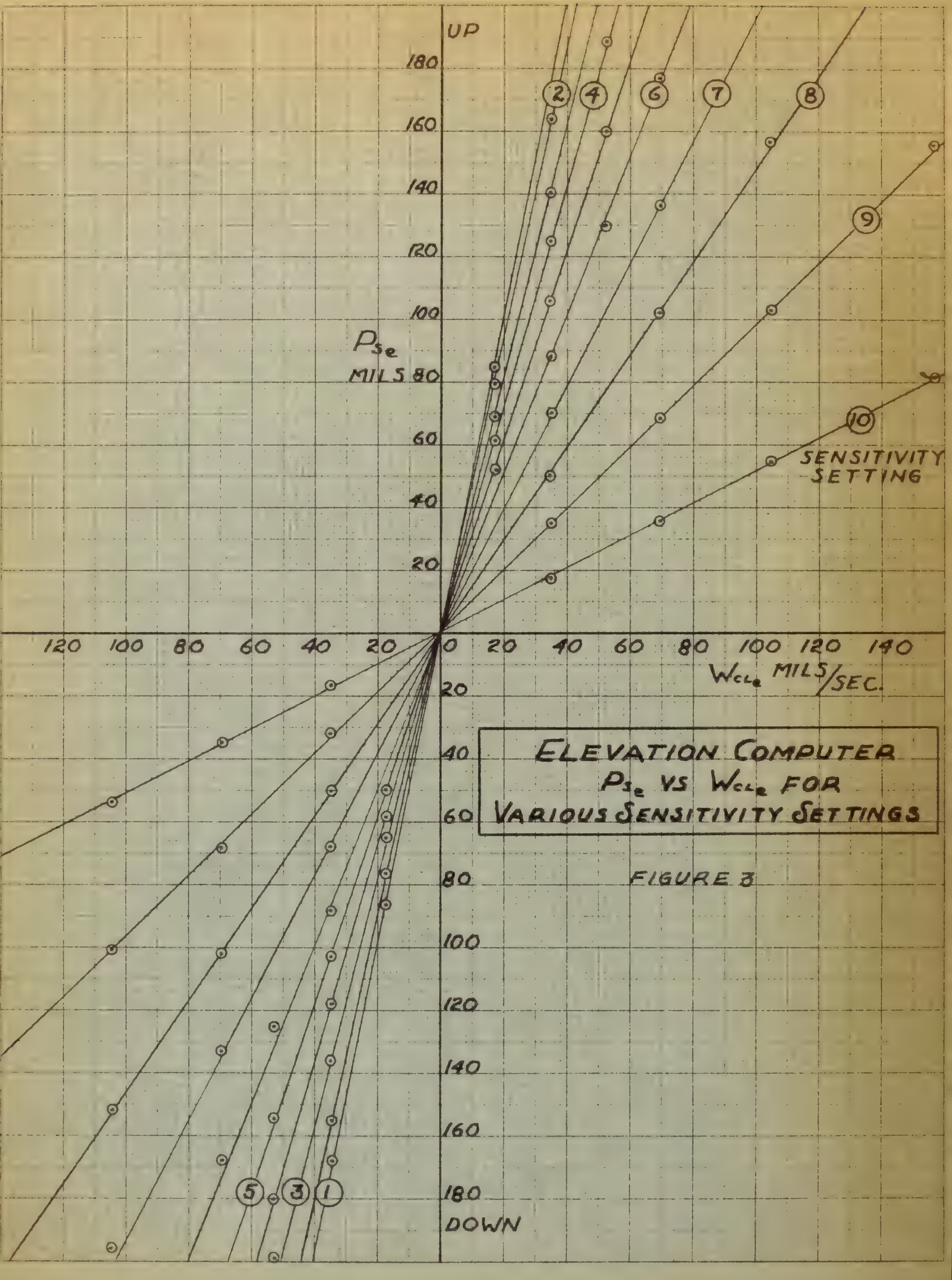
SIMPLIFIED
BLOCK DIAGRAM
3-GYRO GUNSIGHT
FIGURE 1
ANGULAR VELOCITY ABOUT ELEVATION AXIS
Wie
ELEV. S.D.F. GYRO UNIT
ELEV. DAMPER
GYRO LINKAGE
ELEV. ELASTIC RESTRAINT
ELEVATION COMPUTER SHAFT
Ace
ELEV. PICKOFF (CONSTANT EXCITATION)
e(Ace)
VOLTAGE PROPORTIONAL TO Ace
AMP.
ELEV. SERVO AMP.
ELEV.
MIRROR
Pse
CROSS ROLL DAMPER
CROSS ROLL COMPUTER SHAFT
Acr
CROSS ROLL PICKOFF #1
VOLTAGE PROPORTIONAL TO PRODUCT OF Acd AND Acr
EXCITATION CURRENT
Ps
ANGULAR VELOCITY ABOUT ROLL AXIS
Wir
CROSS ROLL S.D.F. GYRO UNIT
SENSI-TIVITY AMPLI-FIER
CROSS ROLL ELASTIC RESTRAINT
CROSS ROLL PICKOFF #2
VOLTAGE PROPORTIONAL TO PRODUCT OF Ace AND Acr
iAce
iAcd
DEFL. SERVO AMP.
DEFL.
Psd
DEFL. DAMPER
Acd
ANGULAR VELOCITY ABOUT DEFLECTION AXIS
Wid
DEFL. S.D.F. GYRO UNIT
DEFLECTION COMPUTER SHAFT
DEFL. PICKOFF (CONSTANT EXCITATION)
eAcd
VOLTAGE PROPORTIONAL TO Acd
DEFL. ELASTIC RESTRAINT



(K) (L) (M) (N) - STATIC SENSITIVITY ADJUSTMENT POTENTIOMETERS

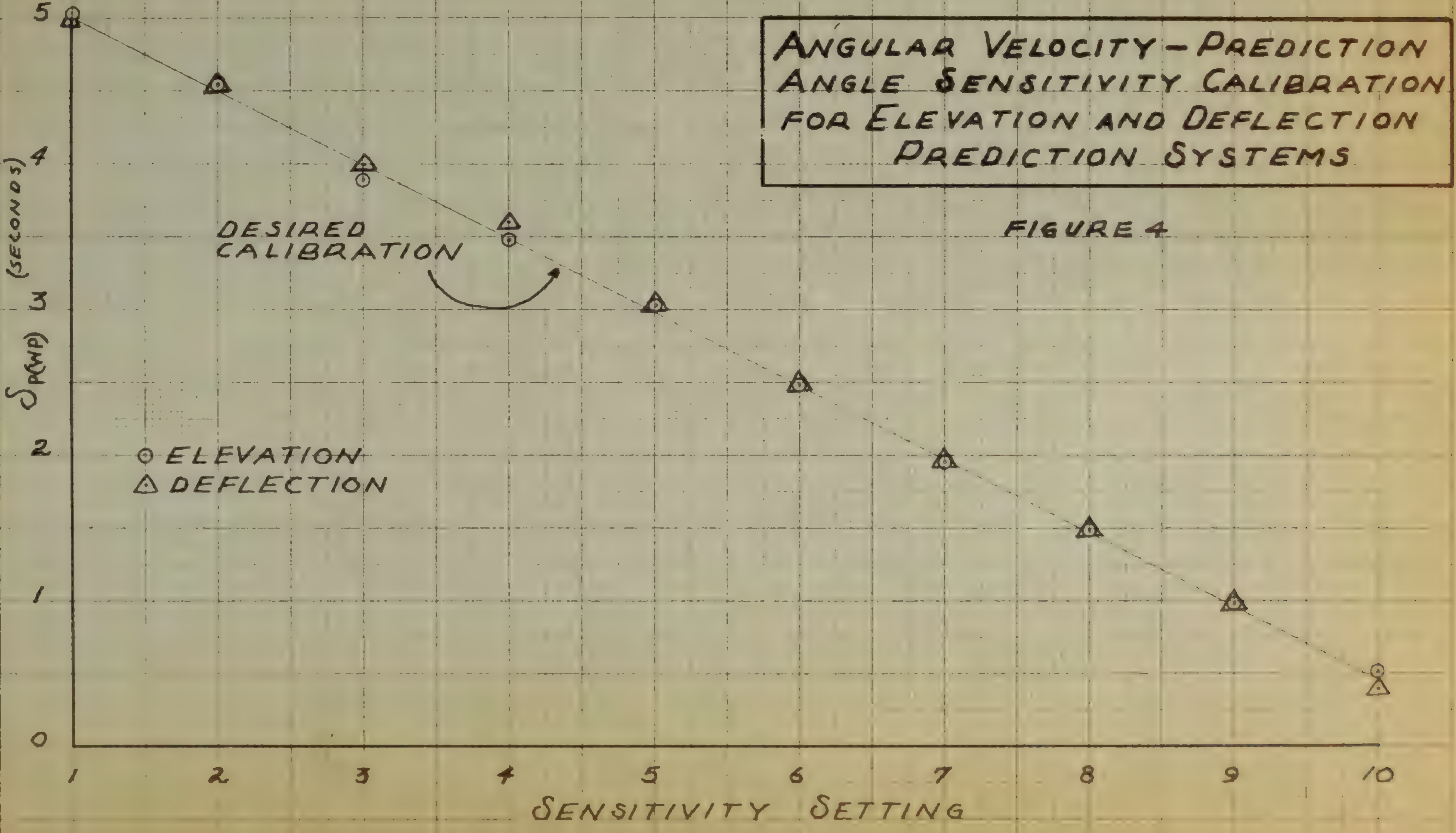
FUNCTIONAL DIAGRAM OF THE STIFFNESS MOTOR ELECTRICAL CIRCUITS

FIGURE 2



UP
DOWN
P_{s_e} MILS
W_{cl_e} MILS/SEC.
120 100 80 60 40 20 0 20 40 60 80 100 120 140
180 160 140 120 100 80 60 40 20
20 40 60 80 100 120 140 160 180
1 2 3 4 5 6 7 8 9 10
SENSITIVITY SETTING
ELEVATION COMPUTER
P_{s_e} VS W_{cl_e} FOR
VARIOUS SENSITIVITY SETTINGS

FIGURE 3



ANGULAR VELOCITY – PREDICTION ANGLE SENSITIVITY CALIBRATION FOR ELEVATION AND DEFLECTION PREDICTION SYSTEMS

FIGURE 4

was directly proportional to viscosity of the damping fluid. The viscosity of the fluid in each computer shaft damper was controlled by a rheostat in the damper heater circuit, and a 12°F change in heater temperature produced a 15 percent change in viscosity.

The method of setting stability number consists of determining the elevation computer system's angular velocity input - rate of change of prediction angle output ratio, $S_{p(W\dot{P})e}$, with the stiffness motor excitation current turned off. Knowing this value, the stability number can be determined from the relationship

$$(SN) = \frac{1}{S_{p(W\dot{P})e}} - 1$$

The average rate of change of prediction angle was determined by timing a sight elevation change of 300 mils resulting from a known angular velocity input to the elevation computer system.

As a means of determining stability number rapidly, a series of graphs were plotted, Figures 5 and 6 for elevation and Figure 7 for deflection. These graphs are a plot of time for the tracking index to travel 300 mils versus input angular rate, and the equation for the lines is derived as follows:

$$(1) \qquad (SN) = \frac{1}{S_{p(W\dot{P})}} - 1$$

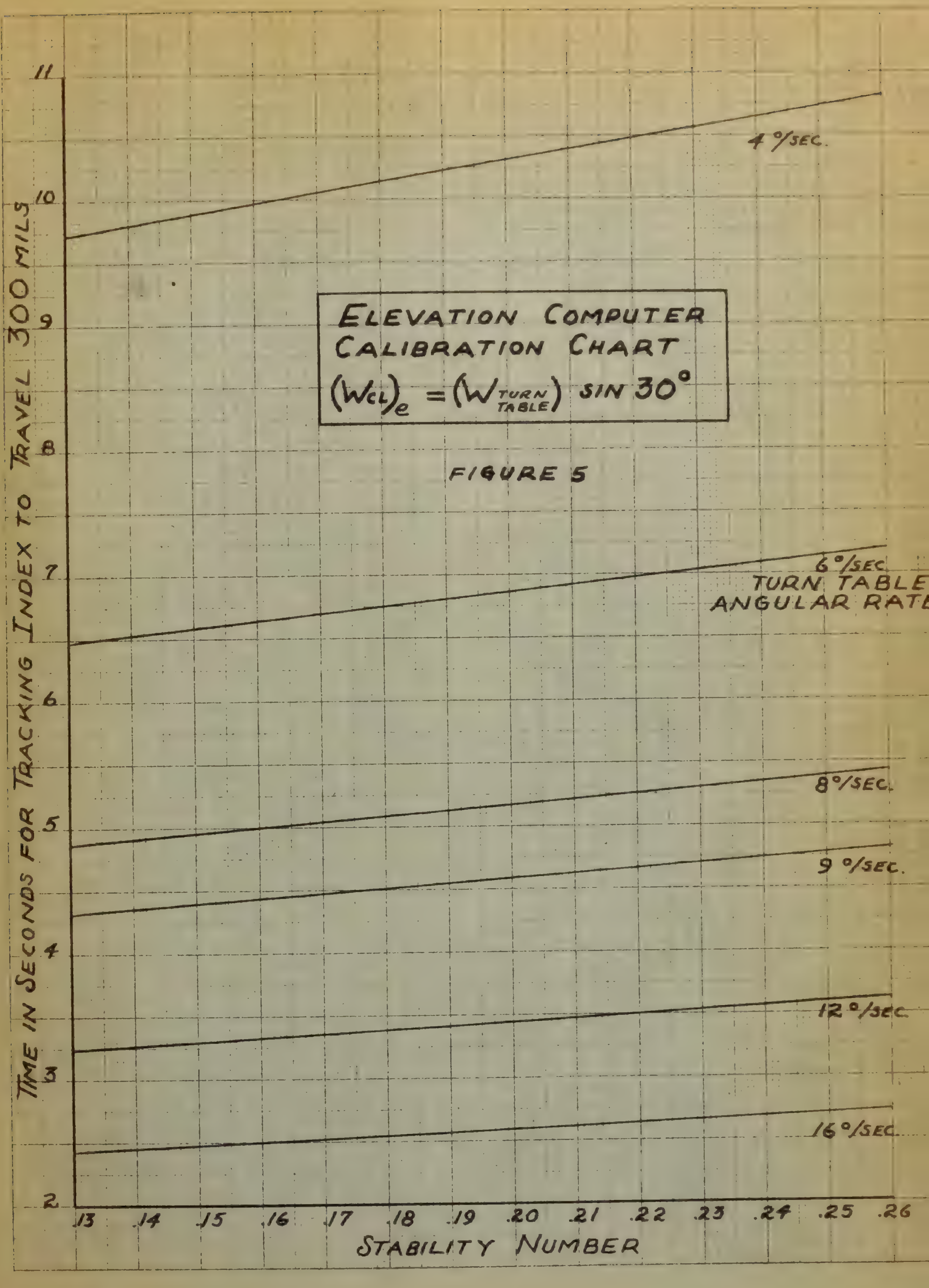
$$(2) \qquad S_{p(W\dot{P})e} = \frac{\dot{P}}{W_{CL}}$$

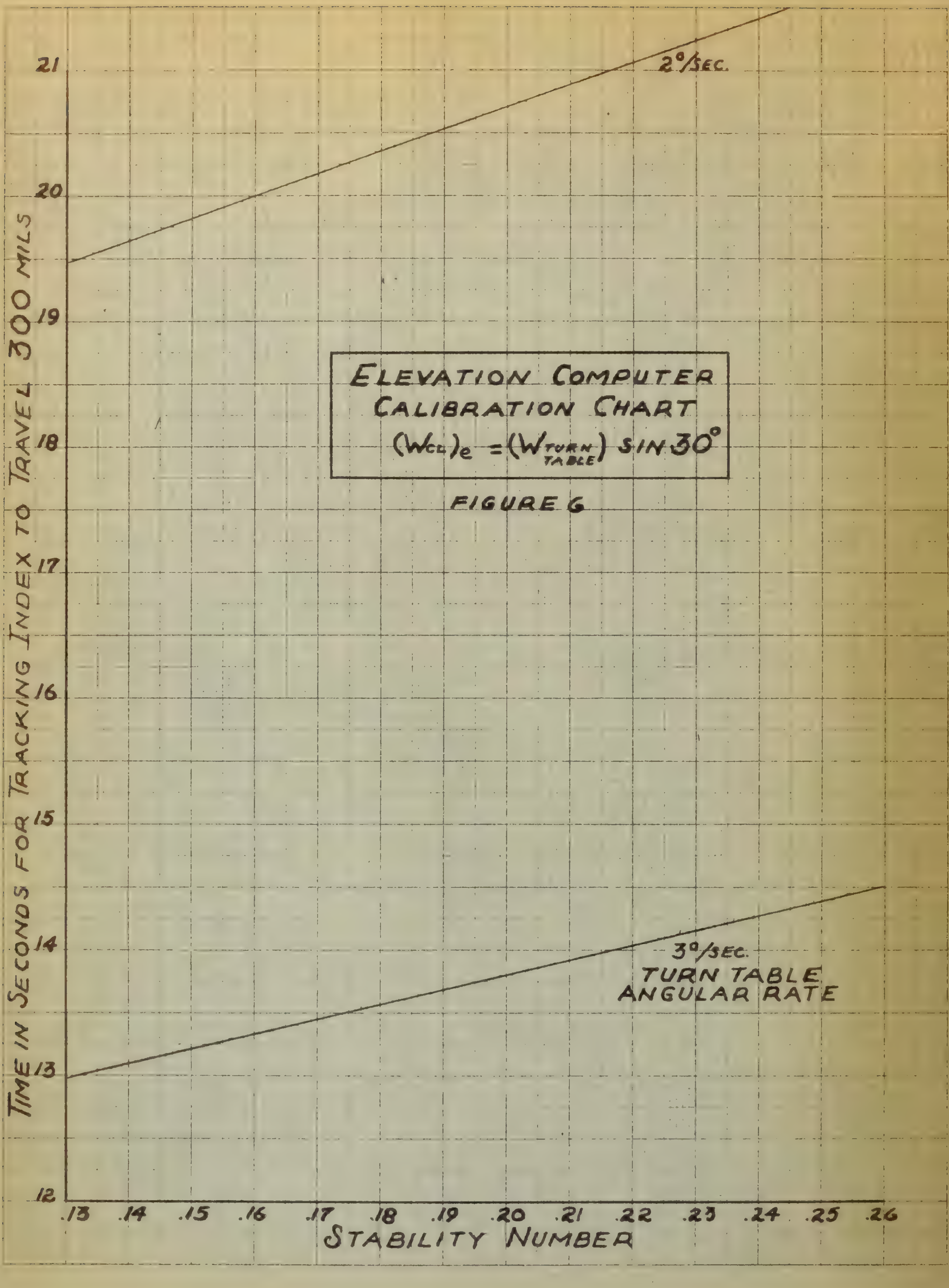
substituting (2) in (1)

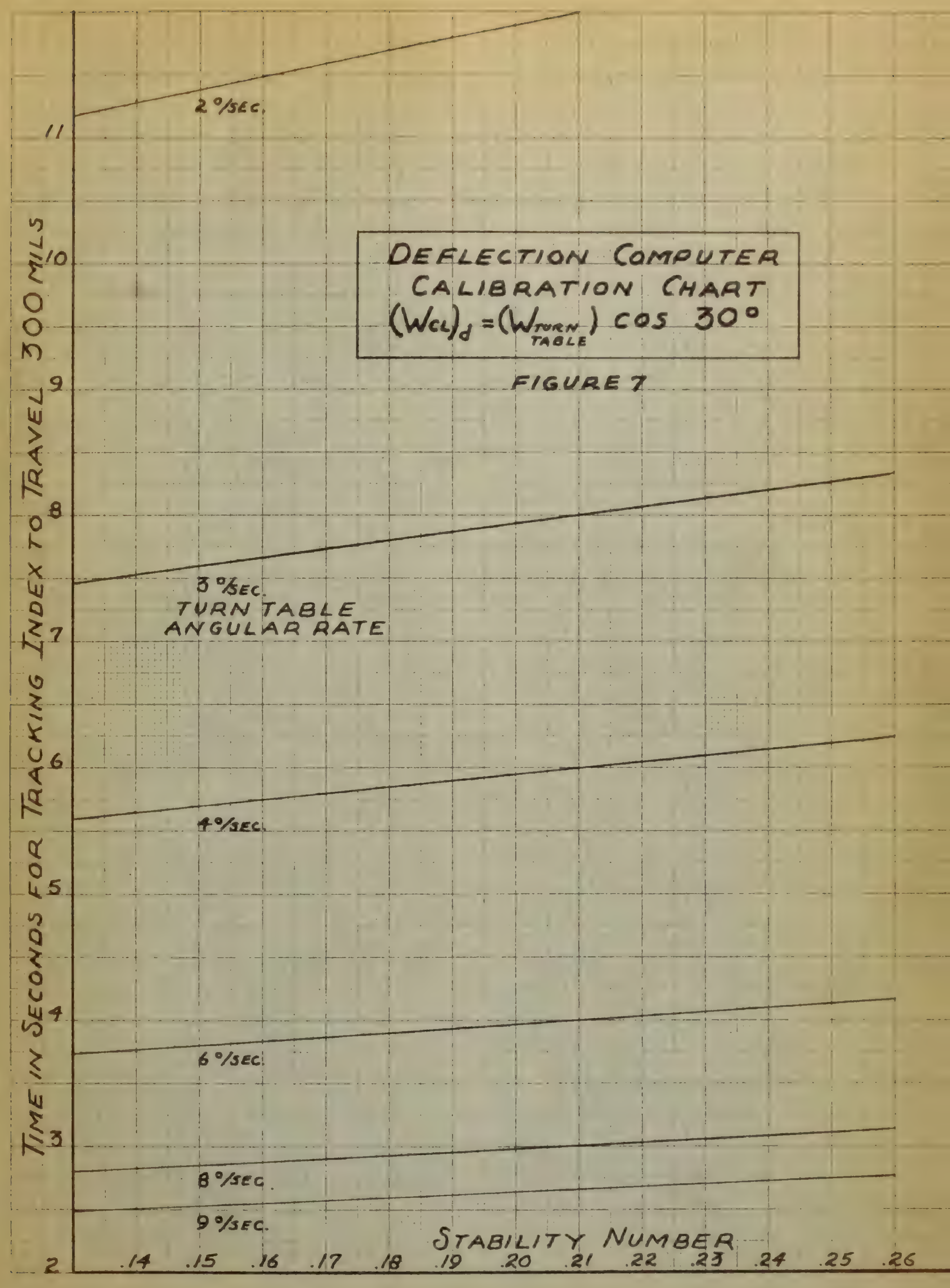
$$(SN + 1) = \frac{W_{CL}}{\dot{P}}$$

$$\text{Let } \dot{P} = \frac{P}{t} = \frac{300}{t} \text{ mils/sec}$$

$$\text{then } t = \frac{300(SN + 1)}{W_{CL}}$$


ELEVATION COMPUTER
CALIBRATION CHART
$(W_{CL})_e = (W_{\substack{TURN\\TABLE}}) \sin 30^\circ$
FIGURE 5
TIME IN SECONDS FOR TRACKING INDEX TO TRAVEL 300 MILS
STABILITY NUMBER
TURN TABLE
ANGULAR RATE
4°/SEC.
6°/SEC.
8°/SEC.
9°/SEC.
12°/SEC.
16°/SEC.
11
10
9
8
7
6
5
4
3
2
.13
.14
.15
.16
.17
.18
.19
.20
.21
.22
.23
.24
.25
.26


ELEVATION COMPUTER
CALIBRATION CHART
$(W_{CL})_e = (W_{TURN\,TABLE}) \sin 30^\circ$
FIGURE 6
2°/SEC.
3°/SEC.
TURN TABLE
ANGULAR RATE
TIME IN SECONDS FOR TRACKING INDEX TO TRAVEL 300 MILS
STABILITY NUMBER
21
20
19
18
17
16
15
14
13
12
.13
.14
.15
.16
.17
.18
.19
.20
.21
.22
.23
.24
.25
.26



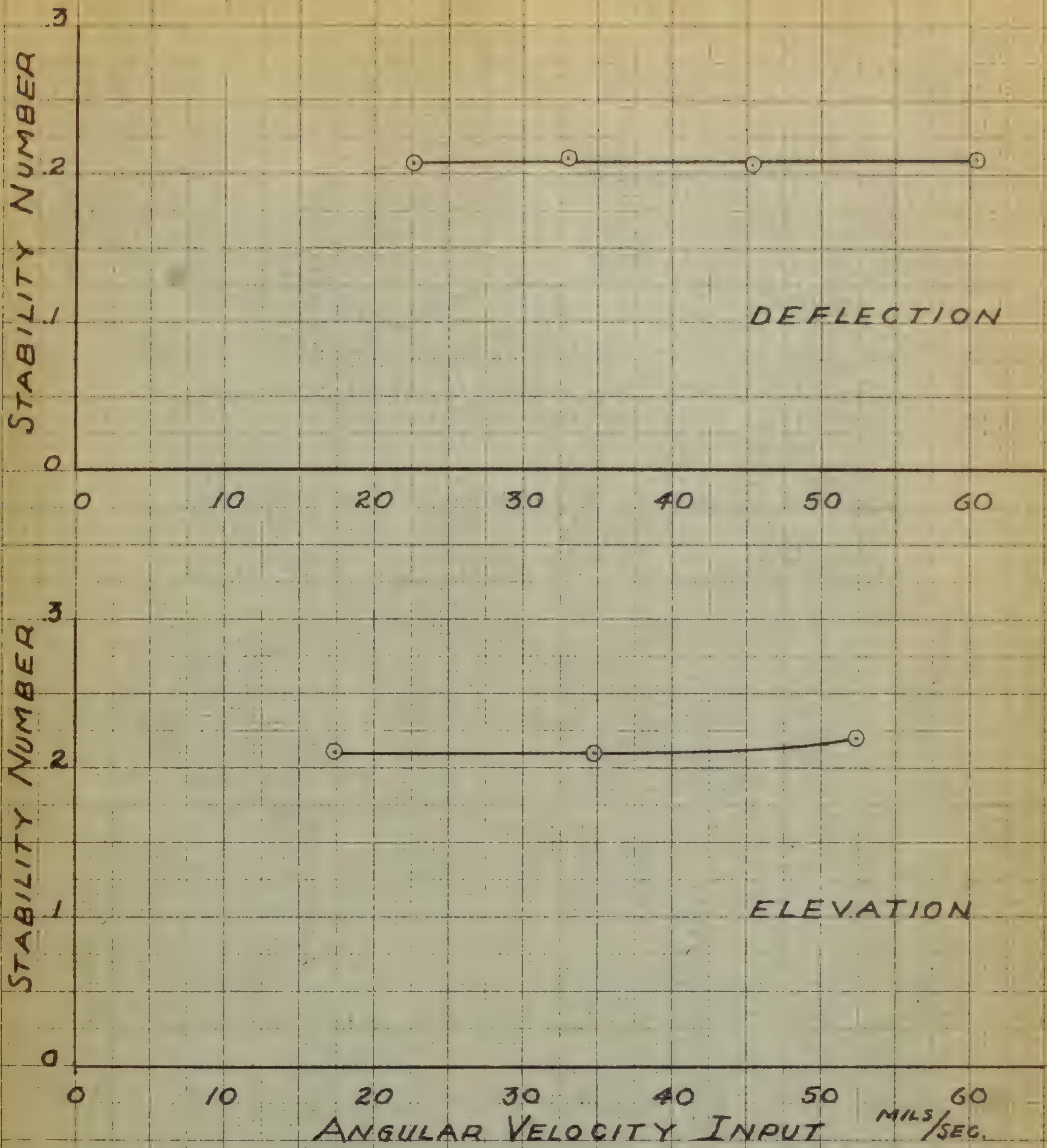
DEFLECTION COMPUTER
CALIBRATION CHART
$(W_{CL})_d = (W_{\text{TURN TABLE}}) \cos 30°$
FIGURE 7
2°/SEC.
3°/SEC.
TURN TABLE
ANGULAR RATE
4°/SEC.
6°/SEC.
8°/SEC.
9°/SEC.
TIME IN SECONDS FOR TRACKING INDEX TO TRAVEL 300 MILS
STABILITY NUMBER
2
3
4
5
6
7
8
9
10
11
.14
.15
.16
.17
.18
.19
.20
.21
.22
.23
.24
.25
.26

In the above formula W_{CL} is the actual input angular velocity in mils per second. This is obtained from turntable angular velocity by multiplying the latter by the sine of 30 degrees for this case, and by the cosine of 30 degrees for the deflection system. However, the turntable angular rate is the parameter listed on the curves to facilitate the laboratory calibration. Thus, if time, t, is taken for a particular traverse of 300 mils using a given value of turntable angular velocity, the stability number can be read directly from the graph.

The stability numbers thus obtained are plotted for the various angular velocity inputs in Figure 8. Final damper temperature setting was 189°F for the elevation computer.

c. MECHANISM CHARACTERISTIC TIME $(CT)_m$

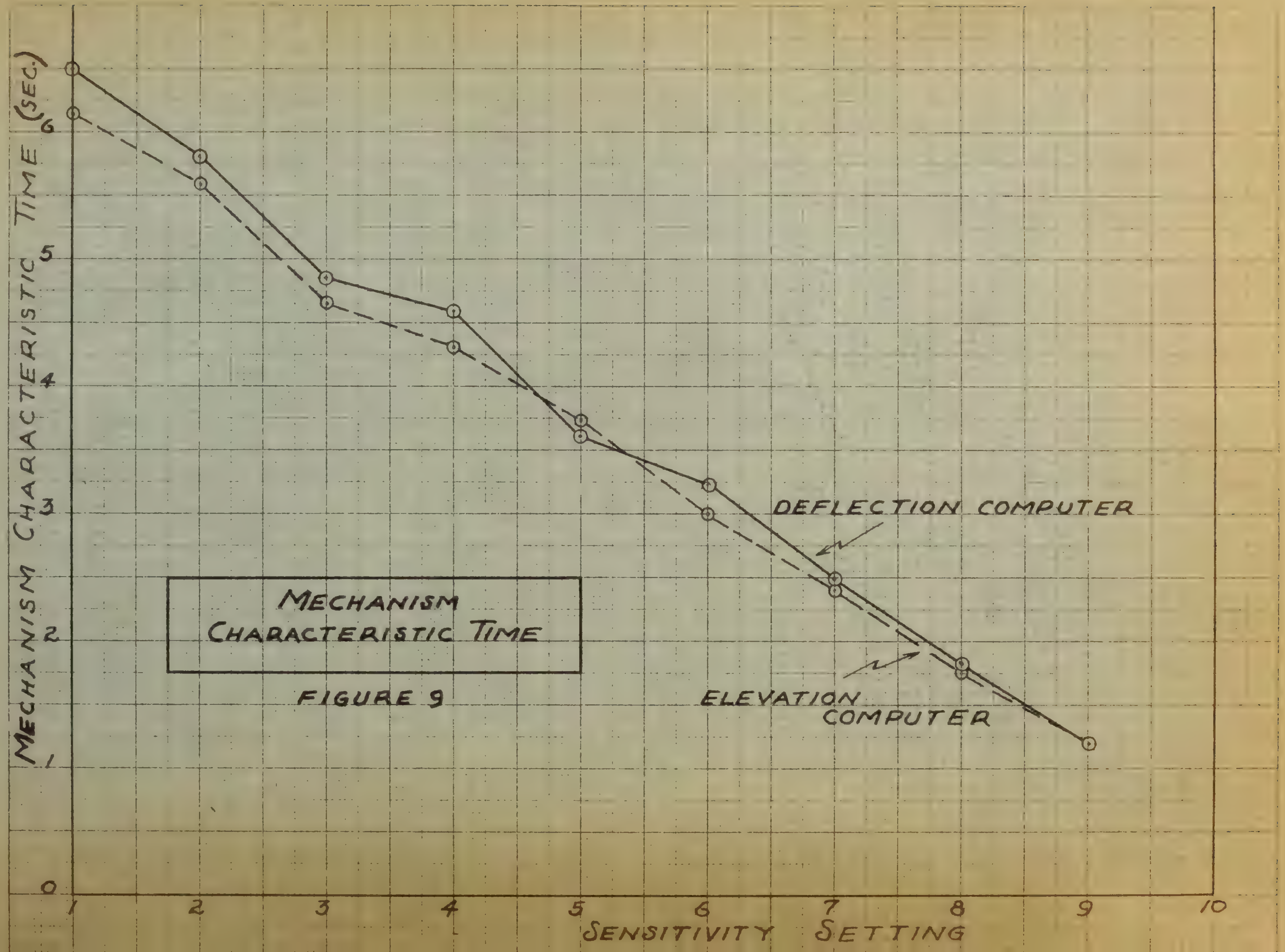
The mechanism characteristic time for the elevation computer system was determined in the following manner. With the case at rest, and only the elevation gyro energized, the elevation computer shaft was deflected manually in order to generate an elevation prediction angle of approximately 150 mils. Using a stop watch, the time interval was determined between a particular elevation prediction angle and another which was 1/e, or 37 percent of the first reading. Data was taken using both elevation and depression angles, and at as many settings of the sensitivity control switch as it was possible to time the tracking index accurately. Due to the inherent inaccuracies of this type of measurement, several readings were taken at each sensitivity setting, and their average assumed to be the correct $(CT)_m$. The values of mechanism characteristic time thus determined are plotted in Figure 9.



STABILITY NUMBER (SN)
FROM FORMULA

$$(SN) = \frac{1}{\delta_{p(w\dot{p})}} - 1$$

FIGURE 8



MECHANISM CHARACTERISTIC TIME (SEC.)
0
1
2
3
4
5
6
7
8
9
10
SENSITIVITY SETTING
DEFLECTION COMPUTER
ELEVATION COMPUTER
MECHANISM CHARACTERISTIC TIME

FIGURE 9

d. CHECK OF CALIBRATION

The sensitivity and the stability number of the elevation computer having been set as described in sections a. and b. above, and the mechanism characteristic time recorded, the overall calibration may be checked from the formula

$$(SN) = \frac{(CT)m}{S_{p(WP)}} - 1$$

The stability number thus determined should agree with the stability number as set in b. The plot of (SN) from the above formula is shown in Figure 10. Since (CT)m and $S_{p(WP)}$ are very nearly equal in magnitude, and their ratio is only slightly different from unity, which is subtracted from the ratio to give the stability number, only a coarse agreement of stability numbers can be expected.

III. CALIBRATION OF THE DEFLECTION SYSTEM

a. DEFLECTION STATIC SENSITIVITY - $S_{p(WP)d}$

For the purposes of this investigation the $S_{p(WP)d}$ was made as nearly as possible the same value as the $S_{p(WP)e}$ for the various sensitivity control settings. In order to accomplish this two current adjustments had to be made so that the current flow through the elevation stiffness motor was not affected by the adjustment of the potentiometer across the deflection coils. In Figure 2, the coarse adjustment was made on the deflection stiffness motor potentiometer marked "M" to bring the $S_{p(WP)d}$ up near its required sensitivity. Then the current through the complete stiffness motor circuit was readjusted by the gain control marked "K" so that the current through the elevation stiffness

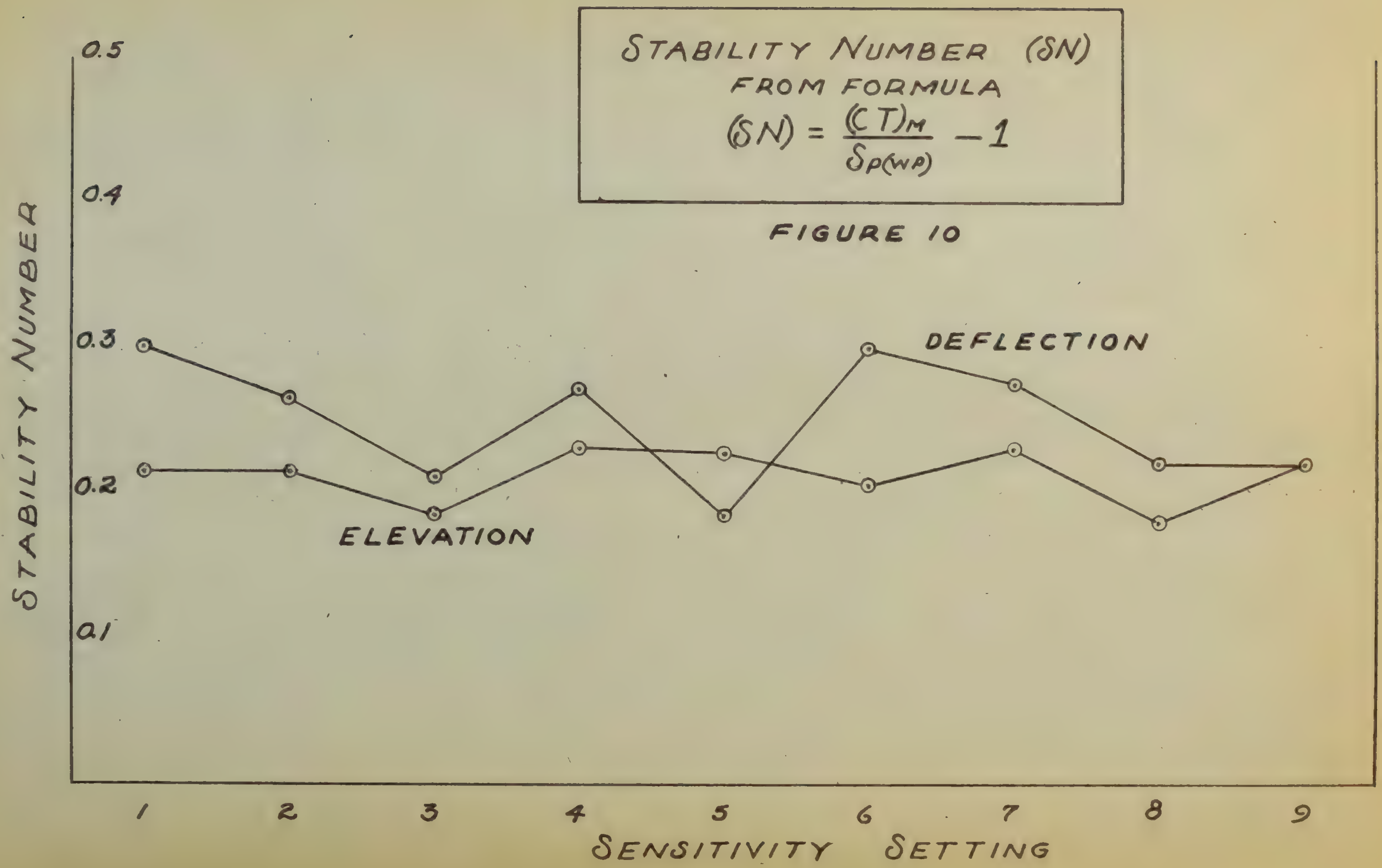

STABILITY NUMBER (SN)
FROM FORMULA
$(SN) = \frac{(CT)_M}{S_{P(WP)}} - 1$
DEFLECTION
ELEVATION
0.5
0.4
0.3
0.2
0.1
STABILITY NUMBER
1
2
3
4
5
6
7
8
9
SENSITIVITY SETTING

FIGURE 10

motor coil was its previous value. A quick check of $S_{p(WP)e}$ on any of the sensitivity control settings could verify this adjustment. Not having changed the position of the computer case on the turntable from its position for the $S_{p(WP)e}$ tests, the turntable angular velocity was modified by the cosine of the tilt of the mounting frame (30 degrees) to give the actual input angular velocity about the deflection axis.

Data of Ps_d versus input angular velocity is plotted in Figure 11. The $S_{p(WP)d}$ is represented by the slope of the line connecting points thus determined for any particular sensitivity setting on the control box. These values of $S_{p(WP)d}$ are plotted against sensitivity setting in Figure 4, which also shows $S_{p(WP)e}$, for comparison.

b. STABILITY NUMBER (SN)

The (SN) for the deflection system was set at 0.20, which was the same value as set on the elevation system. This calibration was made in the same manner as explained in the previous section. The final temperature setting on the deflection computer damper was 173.5°F, and the plot of stability number versus angular velocity input is shown in Figure 6.

c. MECHANISM CHARACTERISTIC TIME (CT)m

Mechanism characteristic time was determined, as described in part 2, section c, and is plotted in Figure 7.

d. CHECK OF CALIBRATION

A check on the overall calibration of the deflection system by determining SN from the formula

$$SN = \frac{(CT)m}{S_{p(WP)d}} - 1$$

was made, and the results are shown in Figure 8.

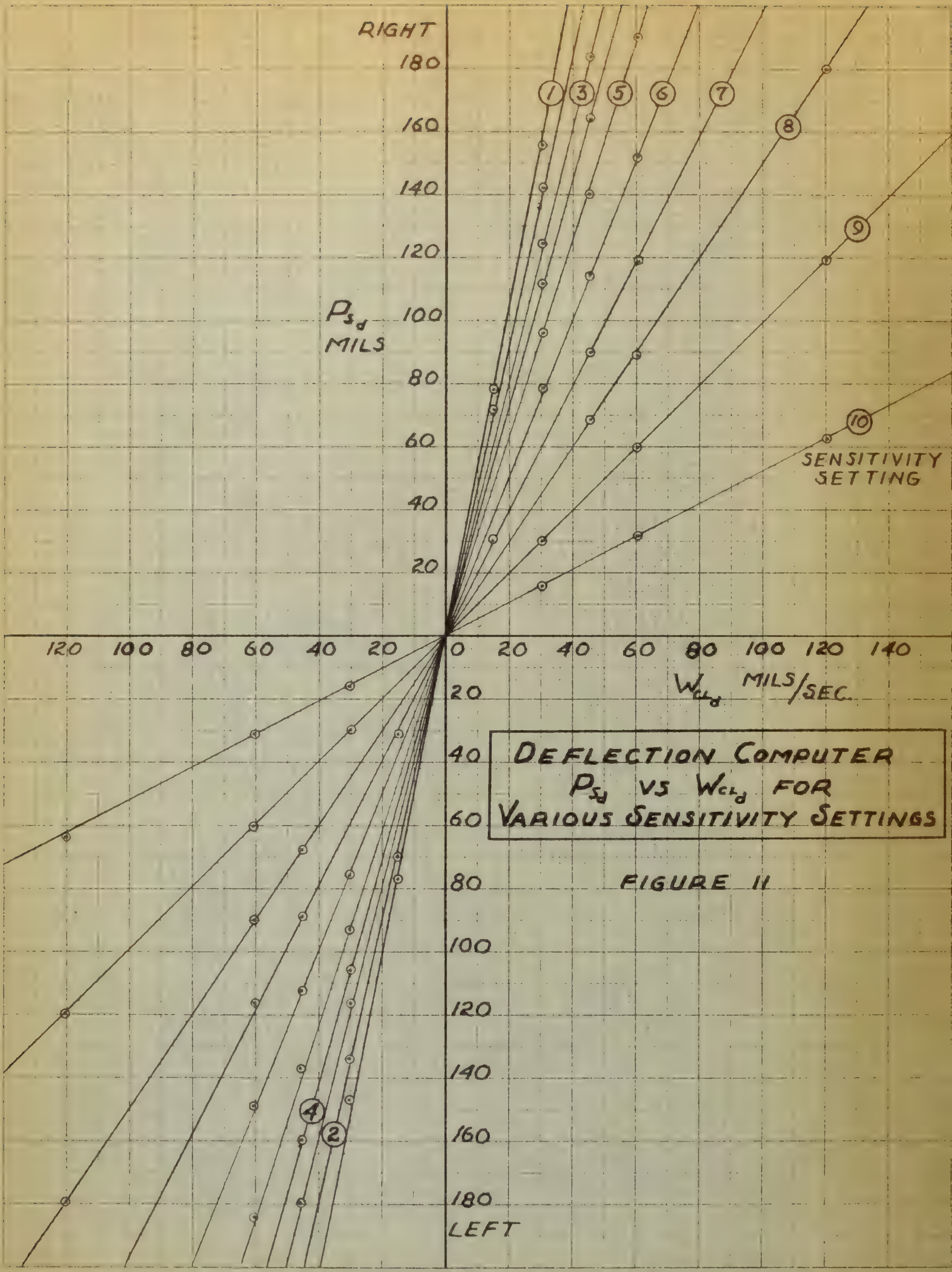

RIGHT
180
160
140
120
100
80
60
40
20
20
40
60
80
100
120
140
160
180
LEFT
P_{s_d} MILS
120 100 80 60 40 20 0 20 40 60 80 100 120 140
W_{cl_d} MILS/SEC.
1
2
3
4
5
6
7
8
9
10
SENSITIVITY SETTING
DEFLECTION COMPUTER
P_{s_d} VS W_{cl_d} FOR
VARIOUS SENSITIVITY SETTINGS

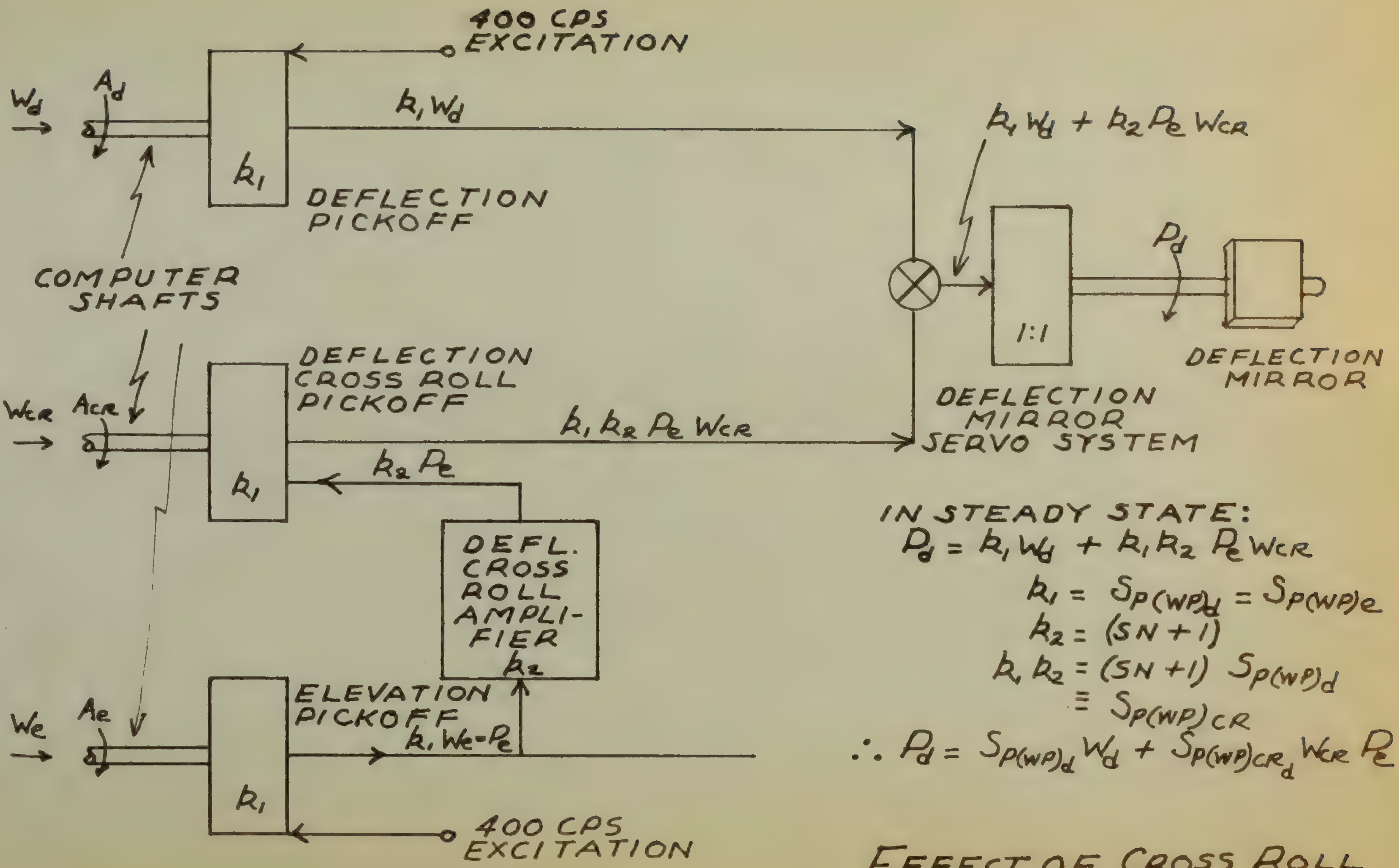
FIGURE 11

IV. CALIBRATION OF THE CROSS ROLL SYSTEM

The calibration of the sight's cross roll correction system was divided into two steps: first, the adjustment the static sensitivity, designated as $S_{p(WP)CR_d}$, of that component of the cross roll system which corrects the deflection prediction angle for cross roll effects, and second, the adjustment of the static sensitivity, designated as $S_{p(WP)CR_e}$, of that component of the cross roll system which corrects the elevation prediction angle for cross roll effects.

The computer case was set up as in the previous calibration with the angular velocity of the turntable, modified by the angle of tilt of the mounting frame, supplying an input to the cross roll computer system. Inspection of the functional diagram picturing the effect of the cross roll system on Ps_d, Figure 12 , shows the inputs desired for the calibration and the factors which are included in the resulting correction. W_{cr} was supplied by the rotation of the tilted computer case. A constant elevation prediction angle, Ps_e, was obtained by deenergizing the elevation computer's gyro and rotating the elevation computer shaft a measured amount and restraining it in that position during the run. The deflection computer's gyro was deenergized so that it made no contribution to the deflection prediction angle. Hence the deflection prediction angle generated was the product of the present Ps_e, the gain (k_2) of the deflection cross roll amplifier, and the angular velocity input (W_{cr}) to the cross roll computer shaft.

With the setup as described above, runs were made and the following data taken: W_{cr}, (turntable speed corrected for mounting frame tilt), Ps_e, Ps_d, the elevation computer system sensitivity setting, and deflection cross roll sensitivity setting.



IN STEADY STATE:

$$P_d = k_1 W_d + k_1 k_2 P_e W_{CR}$$

$$k_1 = S_{P(WP)_d} = S_{P(WP)e}$$

$$k_2 = (SN + 1)$$

$$k_1 k_2 = (SN + 1)\ S_{P(WP)_d}$$

$$\equiv S_{P(WP)CR}$$

$$\therefore P_d = S_{P(WP)_d} W_d + S_{P(WP)CR_d} W_{CR} P_e$$

EFFECT OF CROSS ROLL ON P_d

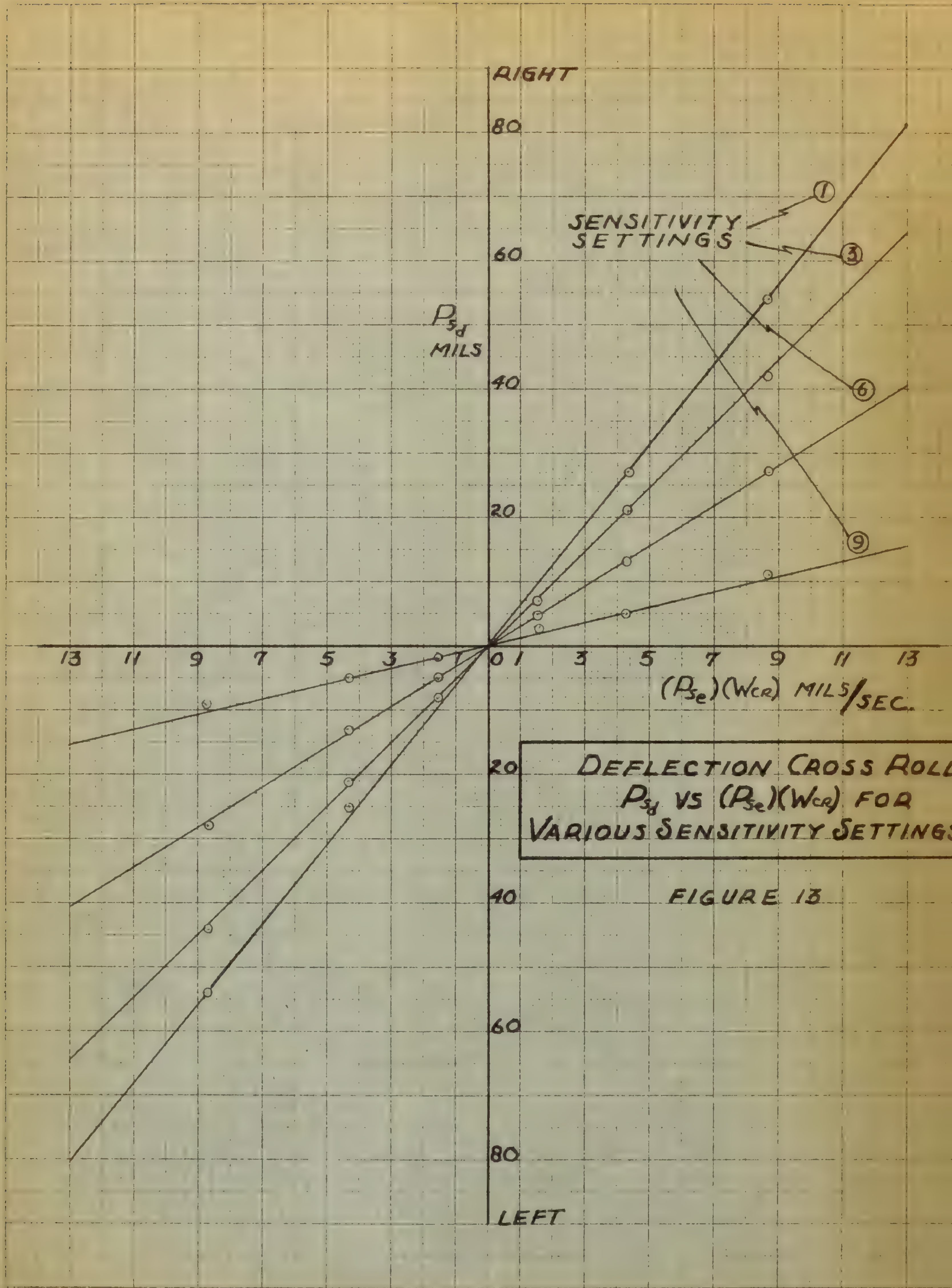
FIGURE 12

From the data, a plot of Ps_d versus the product of cross roll angular velocity (W_{cr}) and the elevation sight prediction angle was made. See Figure 13. The slope of this curve plotted represents the deflection cross roll sensitivity [$S_{p(WP)CR_d}$]. If written in equation form,

$$S_{p(WP)CR_d} = \frac{P_{sd}}{W_{cr} Ps_e}$$

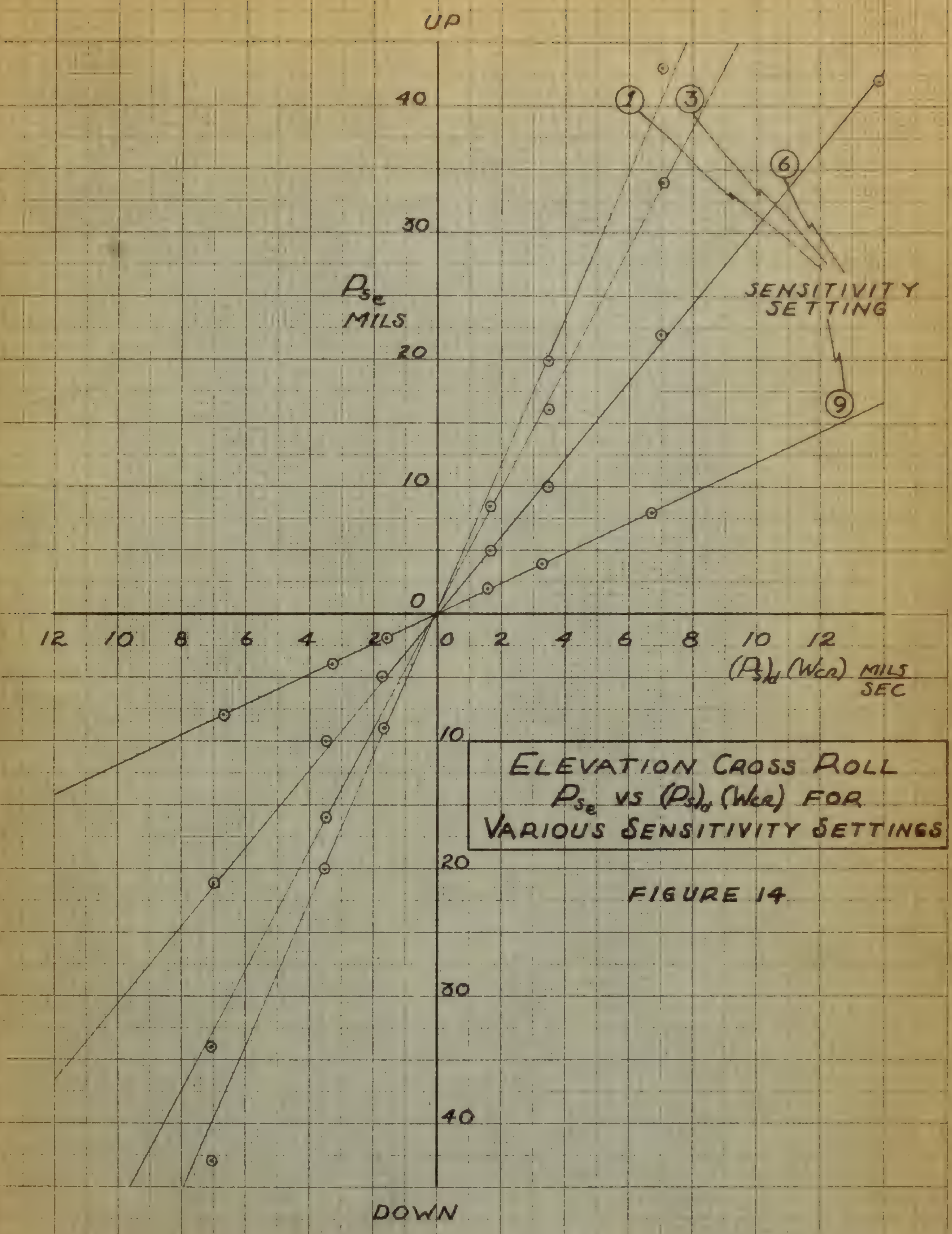
In order to have enough points on the plot to give a representative curve the runs were made with Ps_e value from 50 to 200 mils and with $S_{p(WP)e}$ settings from a minimum to a maximum of 5 seconds. The cross roll sensitivity control unit was designed to give a choice of four sensitivities. As specified these sensitivities were to vary in equal multiples from 1/4, 1/2, 3/4, and 1 of the product of the elevation or deflection sensitivities and the sum (1 + SN). With the maximum cross roll sensitivity setting used the $S_{p(WP)CR_d}$ was adjusted to its proper value by adjusting the gain (k_2) of the deflection cross roll amplifier. To adjust the cross roll sensitivity settings at 3/4, 1/2, and 1/4, the maximum value, an ohmeter was used to calibrate the settings of the variable cathode resistors of the 6SN7 tube in the deflection cross roll amplifier employed as gain controllers. The cathode resistance for a certain setting was adjusted so as to be in proportion to the resistance for maximum sensitivity as the sensitivity for that setting was in proportion to the maximum sensitivity. These resistors are labelled "T," "S," "R," "P," "Q," and "O" in Figure 15, the electrical wiring diagram of the sight system.

Calibration procedure for the elevation cross roll sensitivity was conducted in a similar manner to the procedure described above. Figure 14



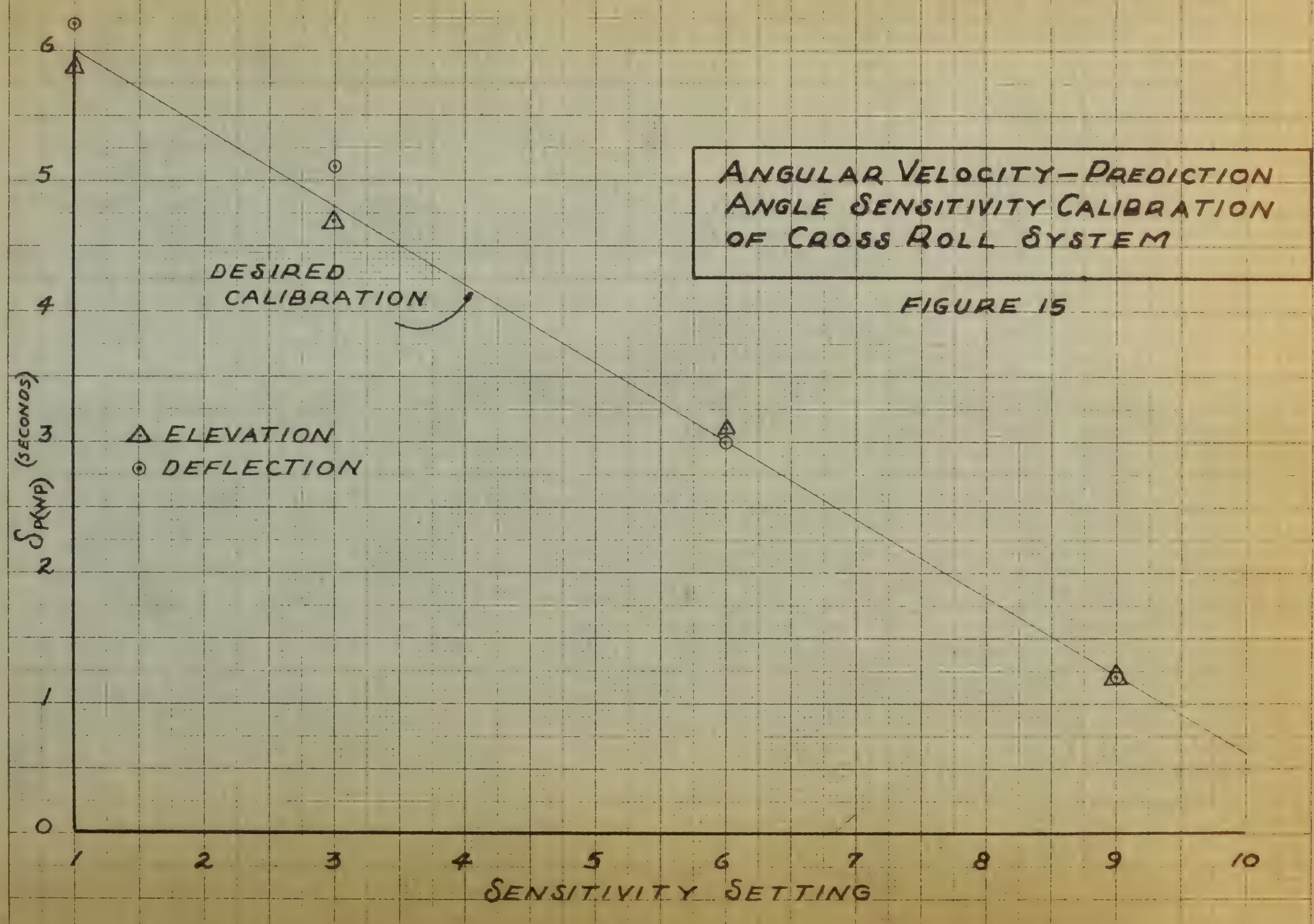
DEFLECTION CROSS ROLL
P_{s_d} VS $(P_{s_e})(W_{CR})$ FOR
VARIOUS SENSITIVITY SETTINGS

FIGURE 13



ELEVATION CROSS ROLL
P_{s_e} VS $(P_s)_d\,(W_{cR})$ FOR
VARIOUS SENSITIVITY SETTINGS

FIGURE 14



ANGULAR VELOCITY–PREDICTION ANGLE SENSITIVITY CALIBRATION OF CROSS ROLL SYSTEM

FIGURE 15

shows Ps_e versus $(Ps_d)(W_{cr})$. Figure 15 is a plot of the results of these calibrations and shows the cross roll sensitivities obtained as a function of the sensitivity setting on the control box.

The cross roll mechanism characteristic time was set equal to the elevation and deflection system (CT)m indirectly while checking the response of the cross roll computer system to a sinusoidal input motion. This procedure is described in the next section wherein, from the results, the (SN) was determined and adjusted to the specified value by varying the temperature of the damper fluid in the damper unit on the cross roll computer shaft.

V. CHECK OF THE SIGHT'S DYNAMIC PERFORMANCE TO A SINUSOIDAL FORCING MOTION

In order to evaluate the dynamic performance of the lead-computing sight, the sight computer case was subjected to a sinusoidal motion, the amplitude and frequency of which was known. The motion of the sight reticle was measured with respect to the amplitude and phase of the forcing motion. The results were determined as a ratio of the amplitude of the response to the amplitude of the forcing motion at zero forcing frequency, and a phase angle of the response, with respect to the forcing motion which was given a negative sign when the output leads the input.

Equipment used to produce a sinusoidal forcing motion consisted of a flat table oscillating about a vertical axis and driven by a variable speed electric motor through a rotating shaft - rocker arm arrangement. The computer case was mounted rigidly on the oscillating table utilizing the tilted mounting frame described in the previous sections.

Mounting the case in this fashion permitted checking the elevation, deflection, and cross roll systems without having to shift the computer case between runs.

To set and measure the amplitude of the forcing motion a beam of light was projected a measured distance from the oscillating table onto a stationary background. The distance was great enough to allow computing the amplitude of angular motion by dividing the distance from the center of oscillation to the light spot on the wall background by the distance through which the light spot travelled when the oscillation table was slowly moved through one-half cycle.

The sight head was mounted so as to allow an observer to watch the sight reticle move with respect to a stationary background a known distance away from the mirror in the sight. When the distance the reticle appears to move on the wall is observed and measured, the angular motion of the sight reticle would be determined and compared to the input amplitude forced on the computer case.

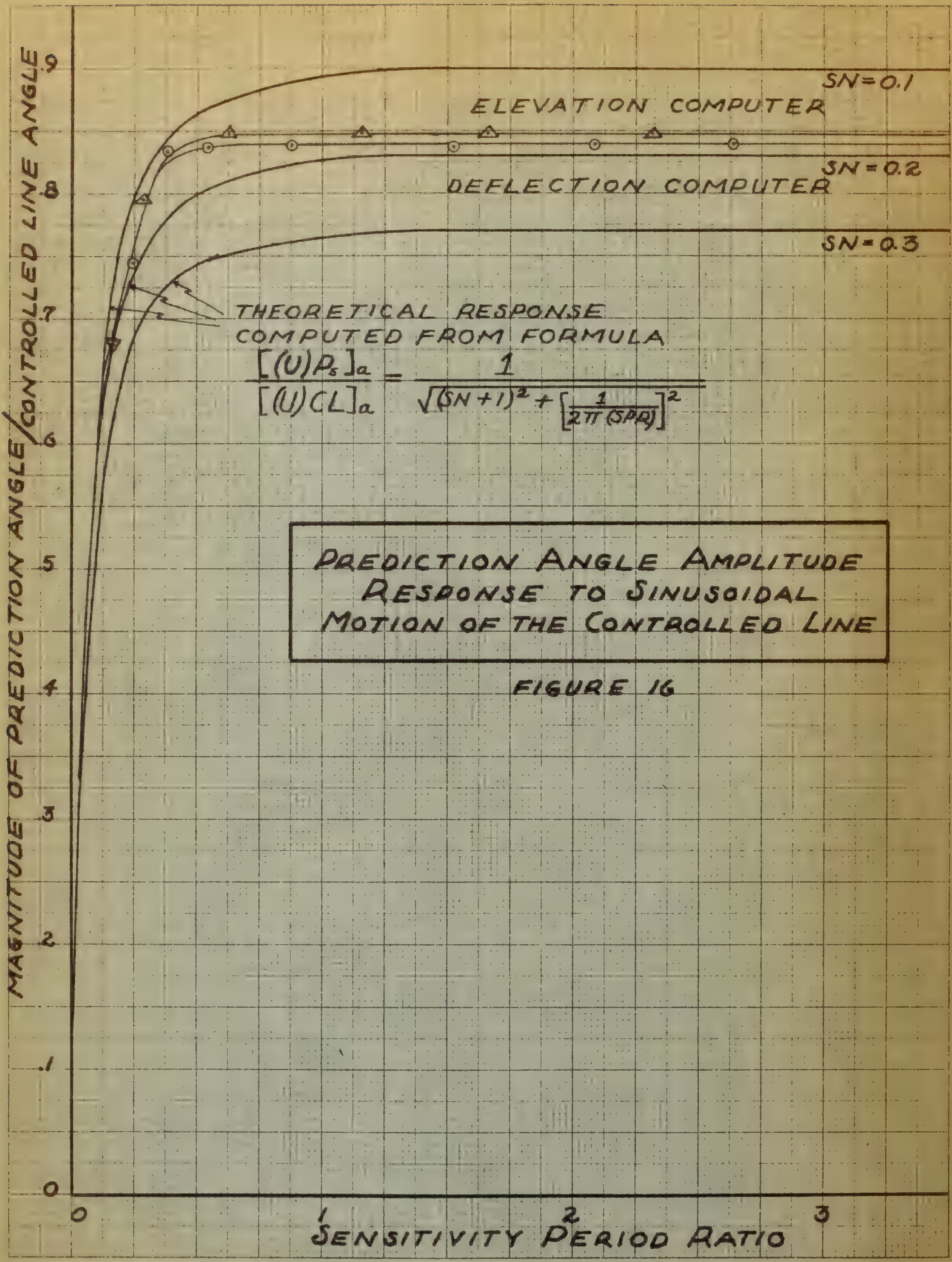
To determine the phase relation, the sight reticle was illuminated by means of a neon light fired in synchronism with motion of the oscillating table through an electrical contactor which made contact once each cycle of the table's motion. Thus after marking the reticle position on the wall for a very slow (zero) input motion, the phase shift for any frequency could be determined by shifting the illuminating contactor control until the reticle flashed on at its position for zero input motion. The angle of shift was read from a protracter scale on the illuminating control.

As in the calibration of the elevation and deflection system sensitivities, the input motion was modified by the angle of tilt of the computer case mounting frame.

To evaluate the elevation and deflection systems' dynamic performance, their amplitude and phase response were measured for various frequencies from near zero to about 1.3 cycles per second. The amplitude response ratio and the phase shift angle were plotted as functions of the sensitivity-period ratio. The static sensitivity had been determined previously for the particular sensitivity control setting used, and the period is the reciprocal of the oscillation frequency in cycles per second. These plots are shown in Figures 16 and 17. Included on these plots are curves determined by theoretical calculation as given in a reference*. As can be seen, the dynamic response of a sight depends on the stability number of its computer system. Therefore, in comparison with the theoretical values plotted on Figures XVI-9 and XVI-17 of the reference* this test could be used to substantiate the (SN) setting on the computer systems.

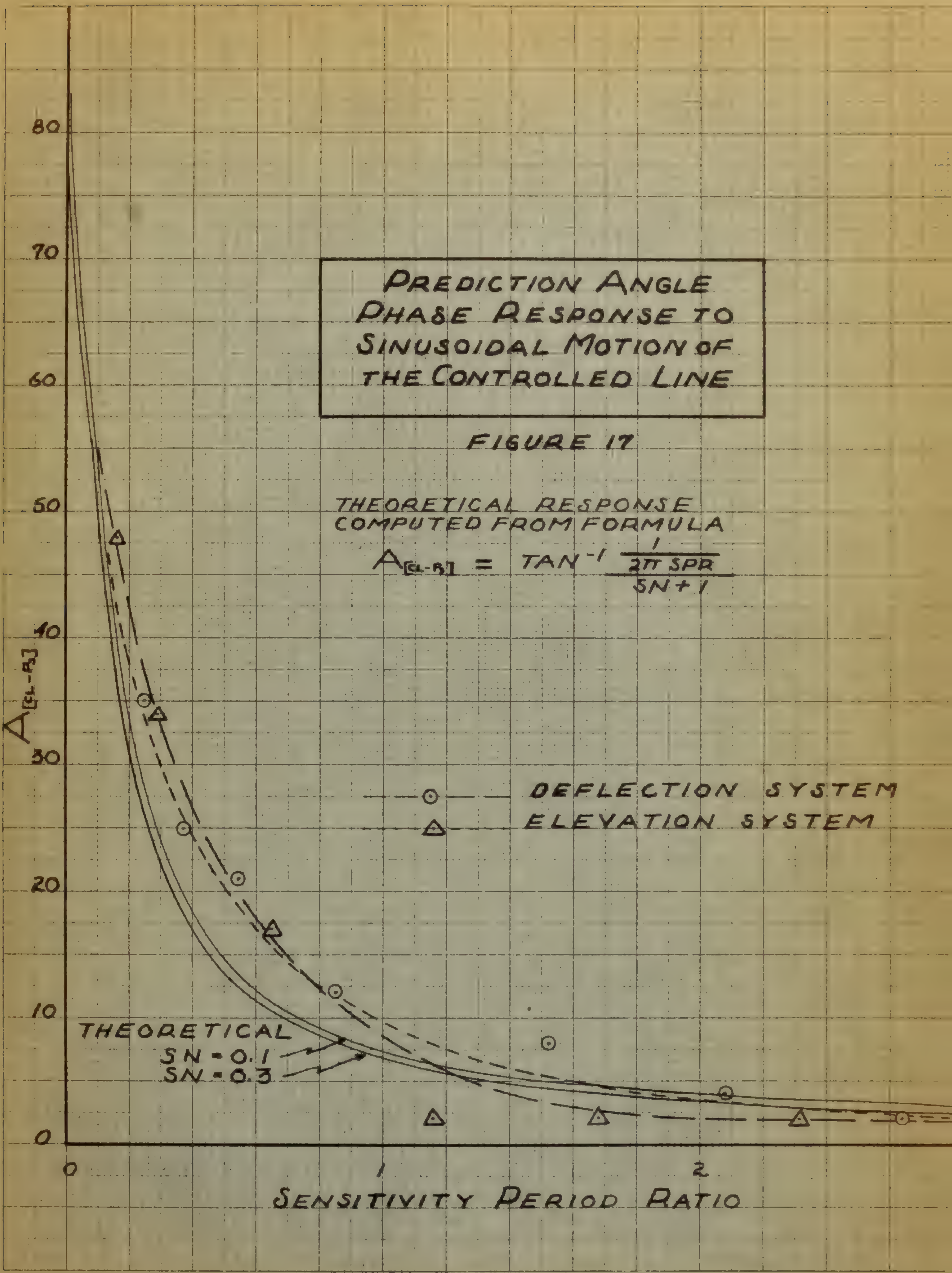
The final check to be made on the oscillating table was to get the response of the cross roll computing system. To do this the elevation gyro wheel was deenergized and its computer shaft deflected and restrained at an angle to produce an elevation prediction angle which was measured. The deflection computer system was made inoperative by deenergizing its gyro. The cross roll sensitivity control was set to a value of $S_{p(WP)CR_d}$ previously determined. Now with the computer case oriented on its tilted mounting frame so that the cross roll gyro received a component of the sinusoidal input motion, the amplitude and phase

* Detailed Theory and Computations for the A-1 Sight for the Control of Gunfire from Fixed Guns, Rocket Fire, and Bombing from Aircraft. Vol. II, Appendix XVI, Sections L and P, prepared by the Instrument Laboratory of the Massachusetts Institute of Technology.



PREDICTION ANGLE AMPLITUDE RESPONSE TO SINUSOIDAL MOTION OF THE CONTROLLED LINE

FIGURE 16


PREDICTION ANGLE
PHASE RESPONSE TO
SINUSOIDAL MOTION OF
THE CONTROLLED LINE
FIGURE 17
THEORETICAL RESPONSE
COMPUTED FROM FORMULA
$A_{[EL-R]} = \tan^{-1} \dfrac{\frac{1}{2\pi\, SPR}}{SN+1}$
DEFLECTION SYSTEM
ELEVATION SYSTEM
THEORETICAL
SN = 0.1
SN = 0.3
$A_{[EL-R]}$
80
70
60
50
40
30
20
10
0
0
1
2
SENSITIVITY PERIOD RATIO

relationship of the deflection prediction angle produced by the cross roll was measured and the data used to compare with the theoretical calculation as in the case of the elevation and prediction systems. See Figures 16 and 17.

This method of checking the cross roll computing system provided a convenient means for adjusting the (SN) of the cross roll system to a specified value, since the (SN) is a parameter affecting the positioning of the curves of Figures 16 and 17 (sinusoidal response curves). The (SN) was adjusted as before by adjusting the temperature of the damper fluid in the damping case on the cross roll computer shaft.

VI. CAMERA INSTALLATION

Two GSAP (gun sight aiming point) cameras, AN-6A, were installed in the F6F for recording data during each run. One camera, attached to the sight head, photographed the tracking index and the target plane; the other, focused on the instrument panel, photographed the following instruments: stop watch, airspeed meter, altimeter, turn and bank indicator, artificial horizon, directional gyro, and accelerometer.

Inasmuch as the standard GSAP camera is provided with a fixed focus lens, focused at infinity, it was necessary to adapt another lens to the camera photographing the instrument panel. The lens used was the Kodak Astigmat, f2.7, 15 mm, which permitted focusing on the instrument panel 30.5 inches distant. No mofidication of the camera frame was necessary; a suitable adapter was manufactured to fit in the lens socket for the fixed-focus lens, and was held in place by a set screw. The adjustable lens was then placed in the adapter.

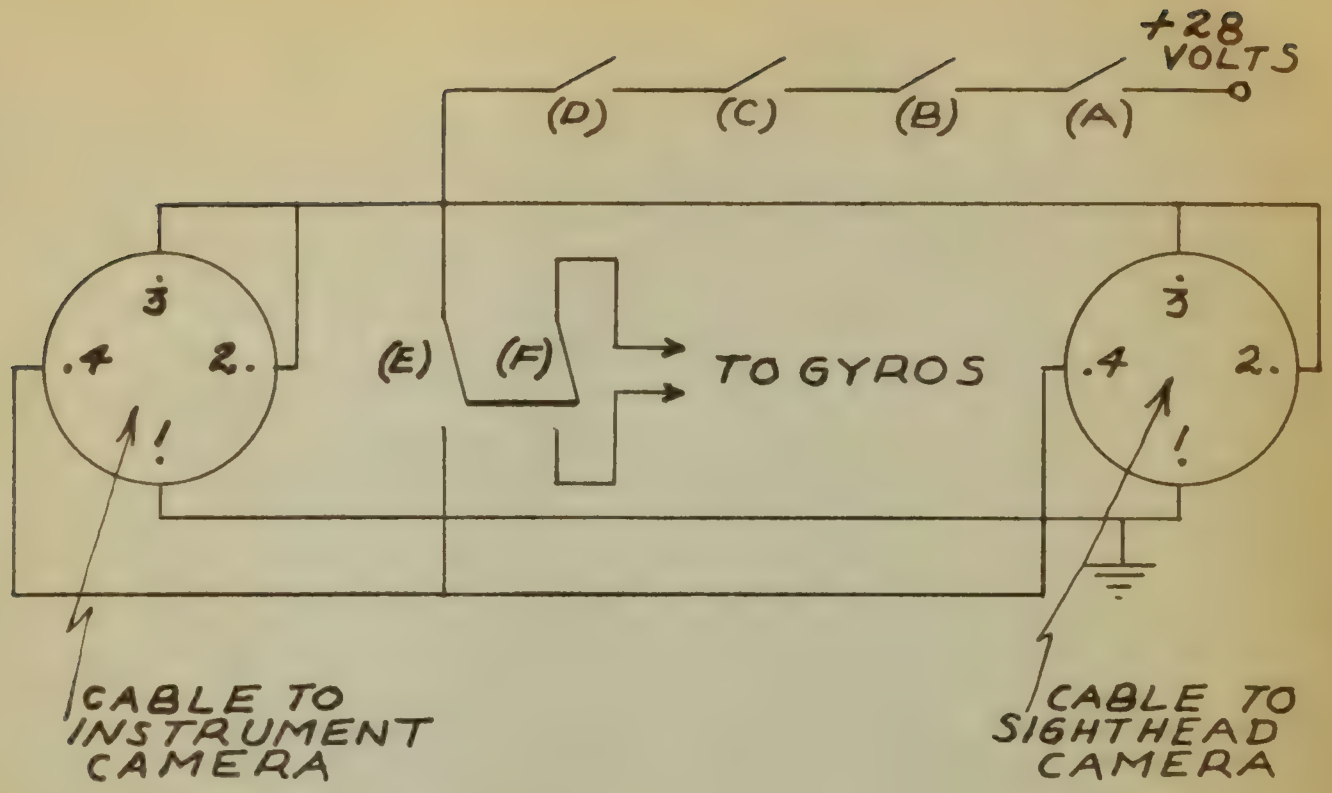
To locate this camera so that it would photograph the desired instruments, it was necessary to mount it in a position just above the left shoulder of the pilot. To do this, the catapult headrest and armor plate were removed, and a suitable bracket for holding the camera was secured to the after bulkhead of the cockpit. Although this arrangement placed the camera and bracket quite close to the pilot's head, it was accepted since it obviated the construction and installation of a separate instrument theatre in the fuselage of the plane.

The external wiring diagram for the camera circuit is shown in Figure 18. The operation of the camera is as follows:

1. Close battery switch, master armament switch, and camera switch.
2. Close gun switch on control stick starting camera.
3. Close coding and gyro caging switches simultaneously at the start of the firing run.

Closing the coding switch actuates a small flag inside each camera in the field of the film and permits synchronization of the two films. When the coding switch is opened prior to releasing the gun switch on the control stick, the film is again coded by the flags. At any intervening time the pilot can flick the coding switch to obtain additional time checks. This coding feature was incorporated in order to make the evaluation of the film easier, since it was a means of positively establishing identical time intervals on the two films.

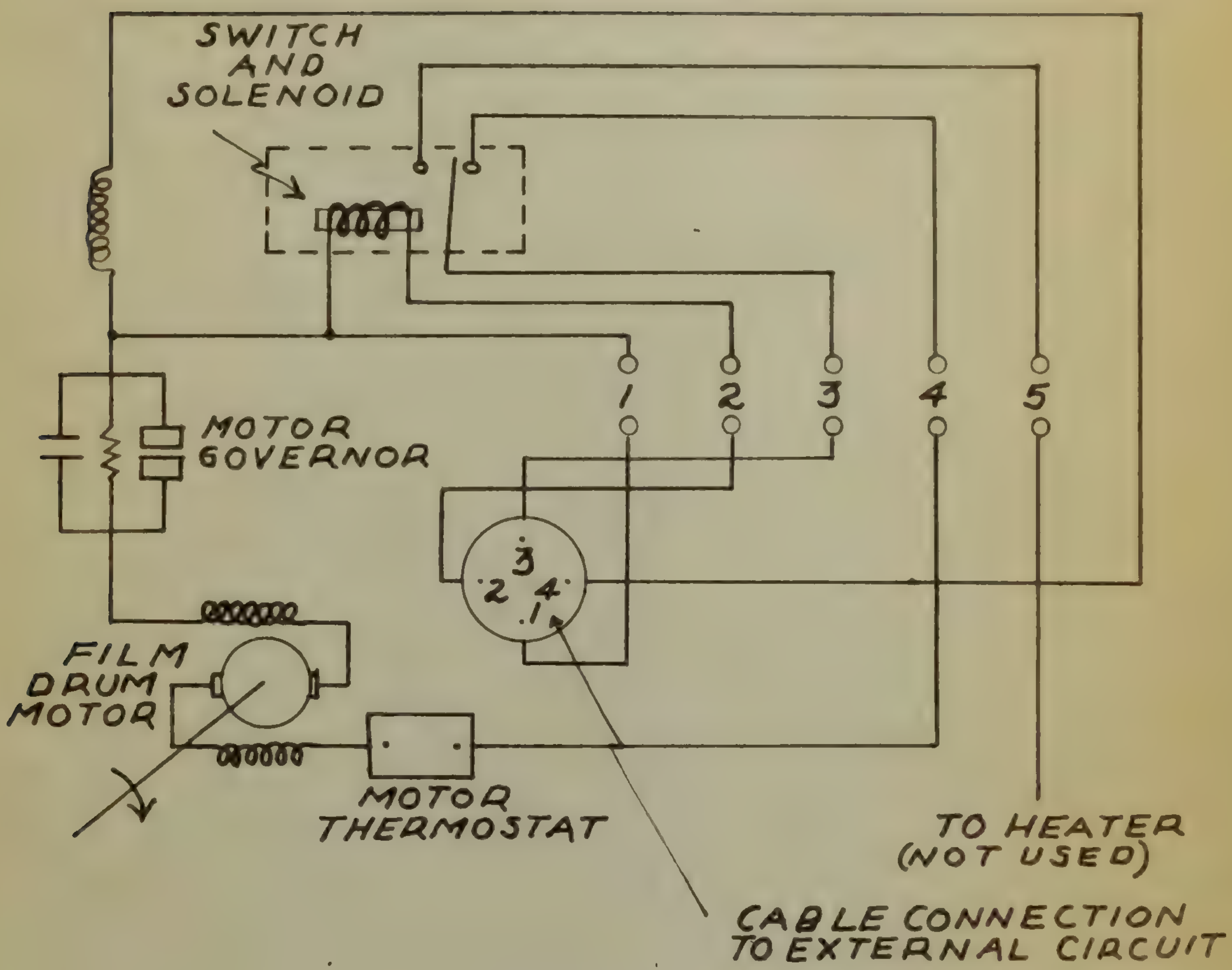
The above separate coding feature necessitated a modification of the standard internal wiring circuit of the GSAP camera. The modified circuit is shown in Figure 19. With the standard circuit, the camera



A. BATTERY SWITCH
B. ARMAMENT SWITCH
C. CAMERA SWITCH
D. TRIGGER SWITCH
E. CODING SWITCH
F. CAGING SWITCH

EXTERNAL WIRING FOR
CAMERA CONTROL CIRCUIT

FIGURE 18



MODIFIED INTERNAL WIRING DIAGRAM FOR GSAP CAMERA

FIGURE 19

runs from one to five seconds (according to the overrun setting) after the gun switch is opened, and the film is coded only at the beginning and end of each run. However, with the modified circuit, additional coding may be obtained through the use of a separate switch. The change within the camera case is to disconnect the lead to the overrun magnet from terminal No. 2, standard circuit, and connect this lead to terminal No. 4, modified circuit. This modified internal circuit, together with the external operating circuit, permits simultaneous uncaging of the gyro and coding of the film, and any additional synchronization coding desired.

VII. INSTALLATION OF THE THREE-GYRO COMPUTING GUNSIGHT'S COMPONENTS IN THE MODEL F6F NAVY AIRCRAFT

a. SIGHT HEAD

The sight head, specially designed for this project, was mounted in the normal gunsight position. A sight mounting bracket was made, and was secured by four bolts to that part of the airplane's structure which normally supports the sight. To prevent any vibration of the sight head, additional supports were employed. These supports consisted of two rigid steel straps running from the sides of the sight to the windshield frame directly above.

The sight reticle caging switch, to be operated by the pilot's left hand, was mounted on the cockpit sill just over the throttle on a switch box which also contained the gun camera's coding switch.

b. PILOT'S CONTROL BOX

The pilot's control box with its master switch, damper heater switch and indicator lights, and sensitivity control switches, was shock-mounted

over the right rudder bar under the pilot's instrument panel by means of two clamps secured to the rudder bar and one bolt attaching to the fire-wall at the rear of the control box.

c. COMPUTER CASE: SERVO AMPLIFIER, DYNAMOTOR, AND INVERTER UNITS

The computer case, servo amplifier, dynamotor, and inverter units were installed in the fuselage of the airplane behind and below the pilot's cockpit. They were mounted on bases previously occupied by night-fighting radar equipment, which was removed from the airplane in order to accommodate the gunsight's equipment. Electrical power for the sight system was obtained from the junction box which contains a fitting for supplying power to the airplane's electrical system from an external source.

d. GUNSIGHT CAMERA REFERENCE MARKER

A gunsight camera reference marker, which consisted of a steel rod with a beaded tip, was mounted ahead of the windshield on the fuselage at a position just aft of the engine nacelle. The purpose of this marker was to provide a reference point in the assessment camera film from which lead angles could be determined.

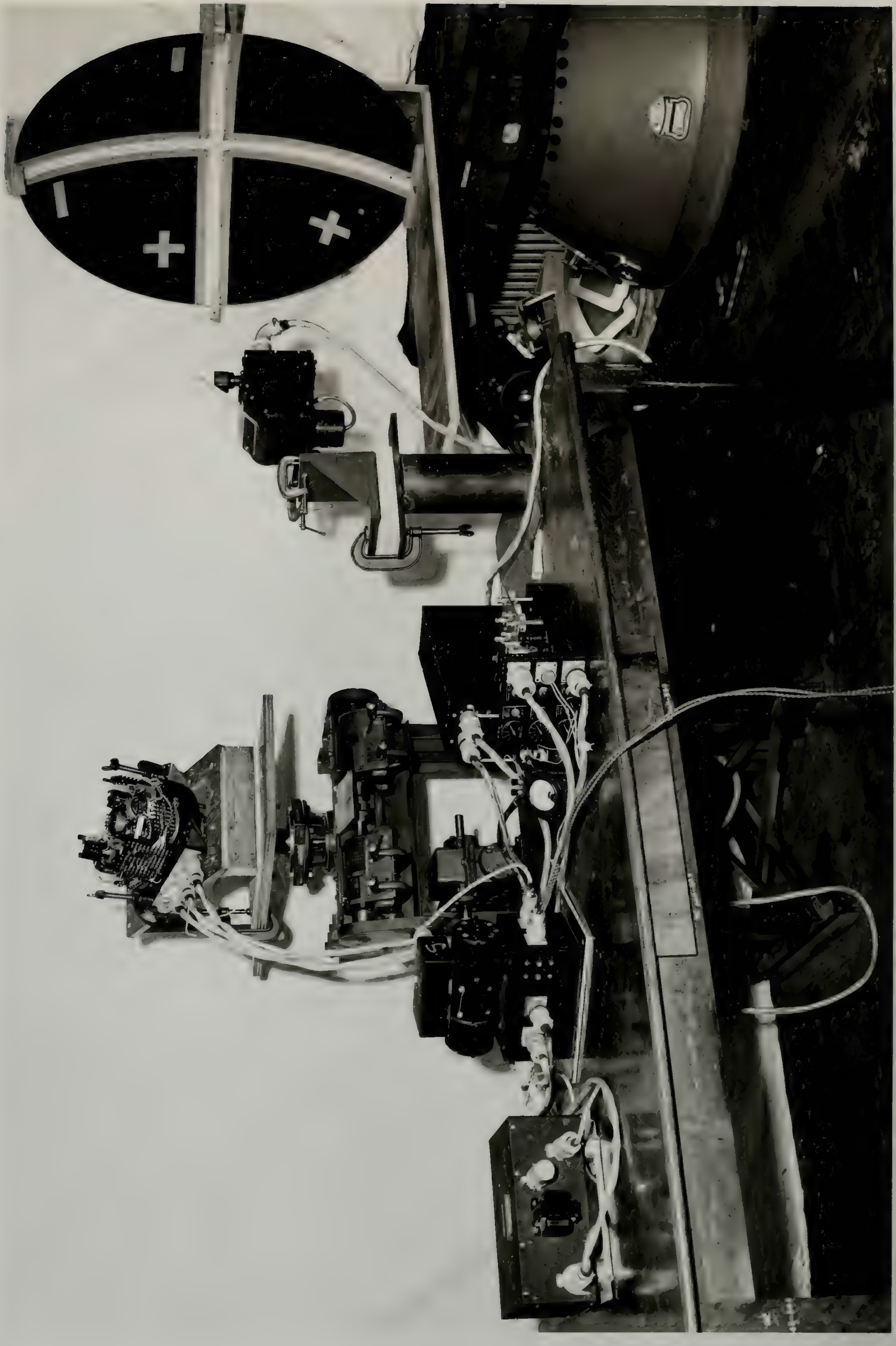


PLATE 1

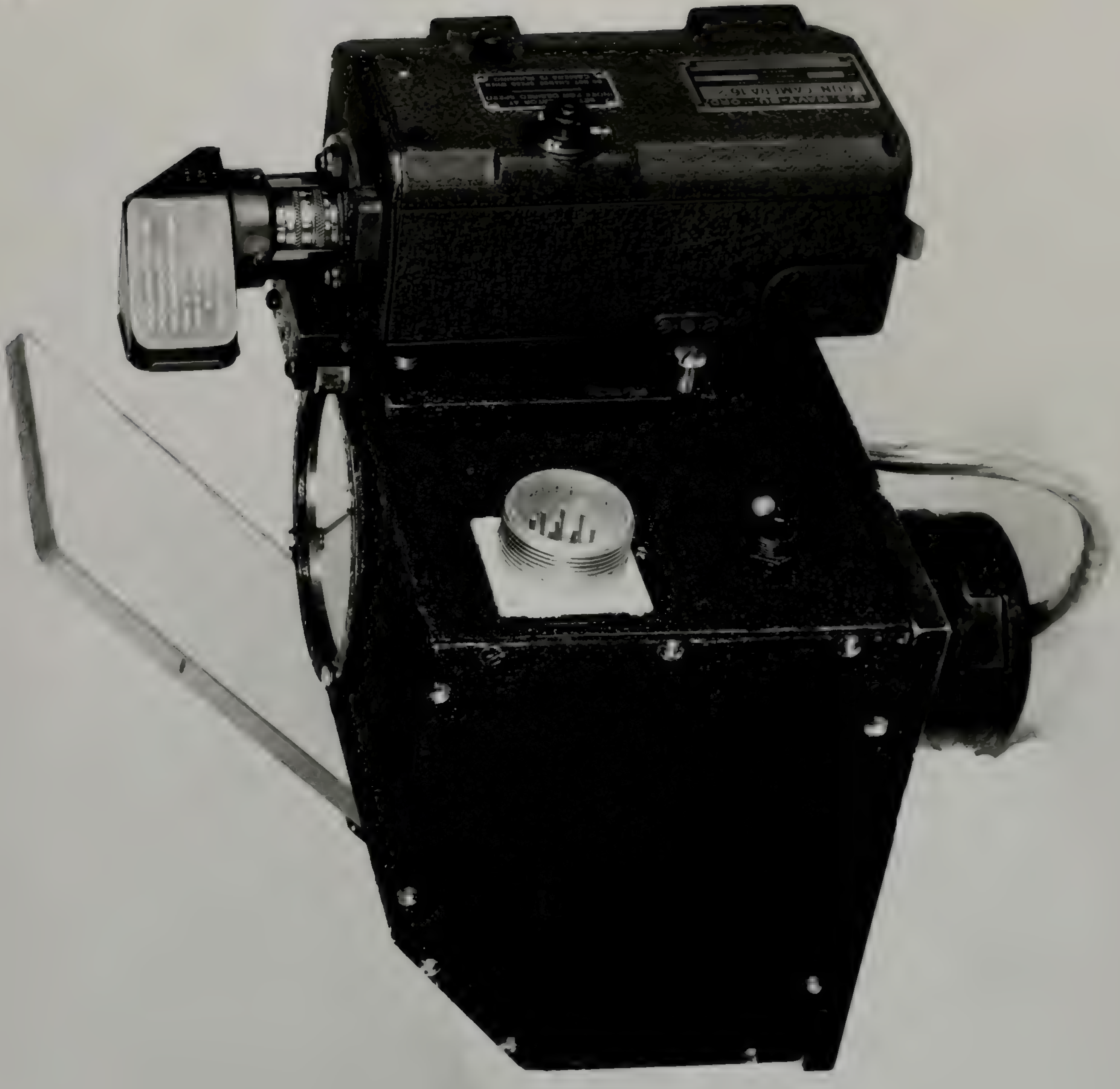


PLATE 2

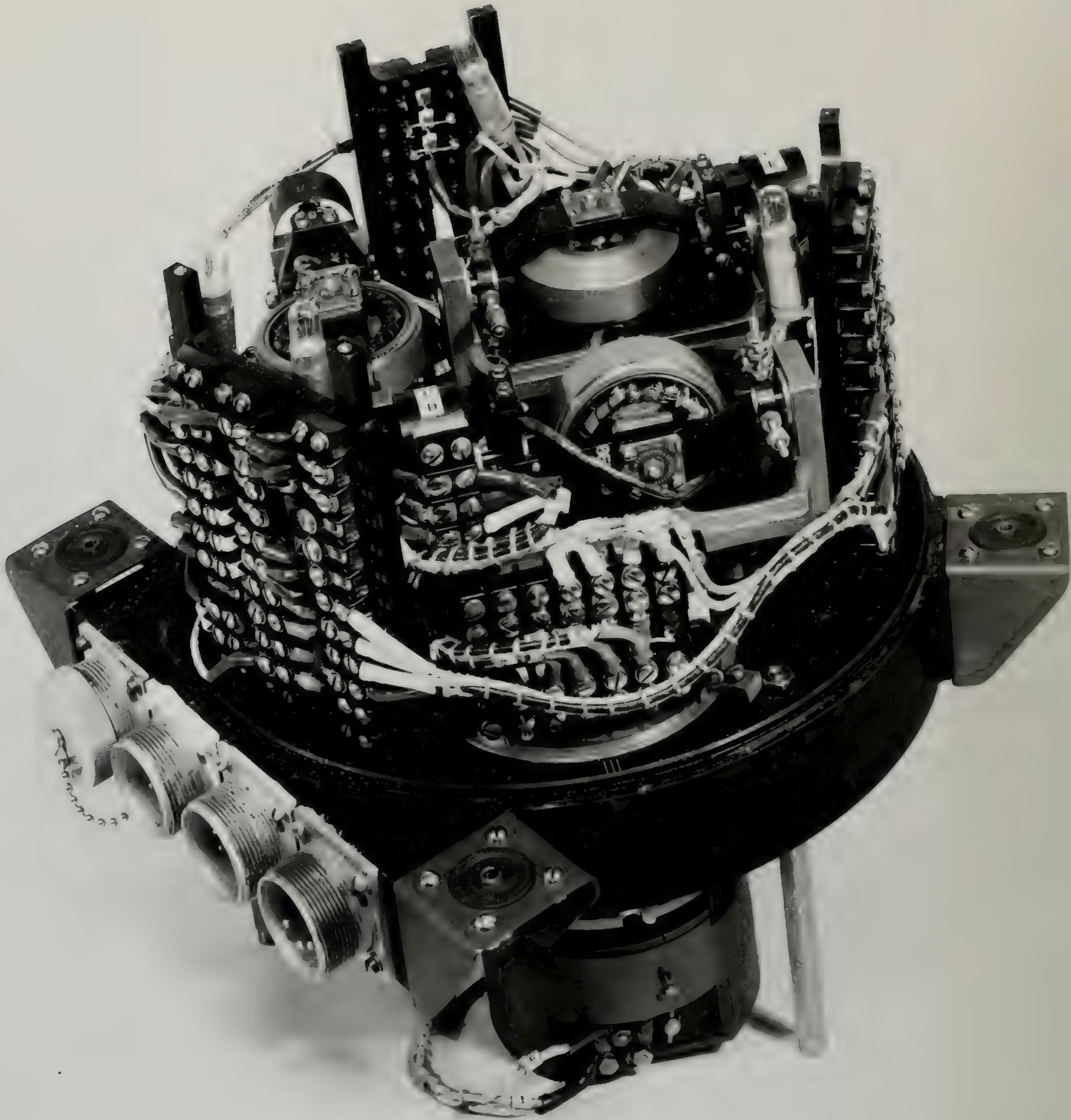


PLATE 3

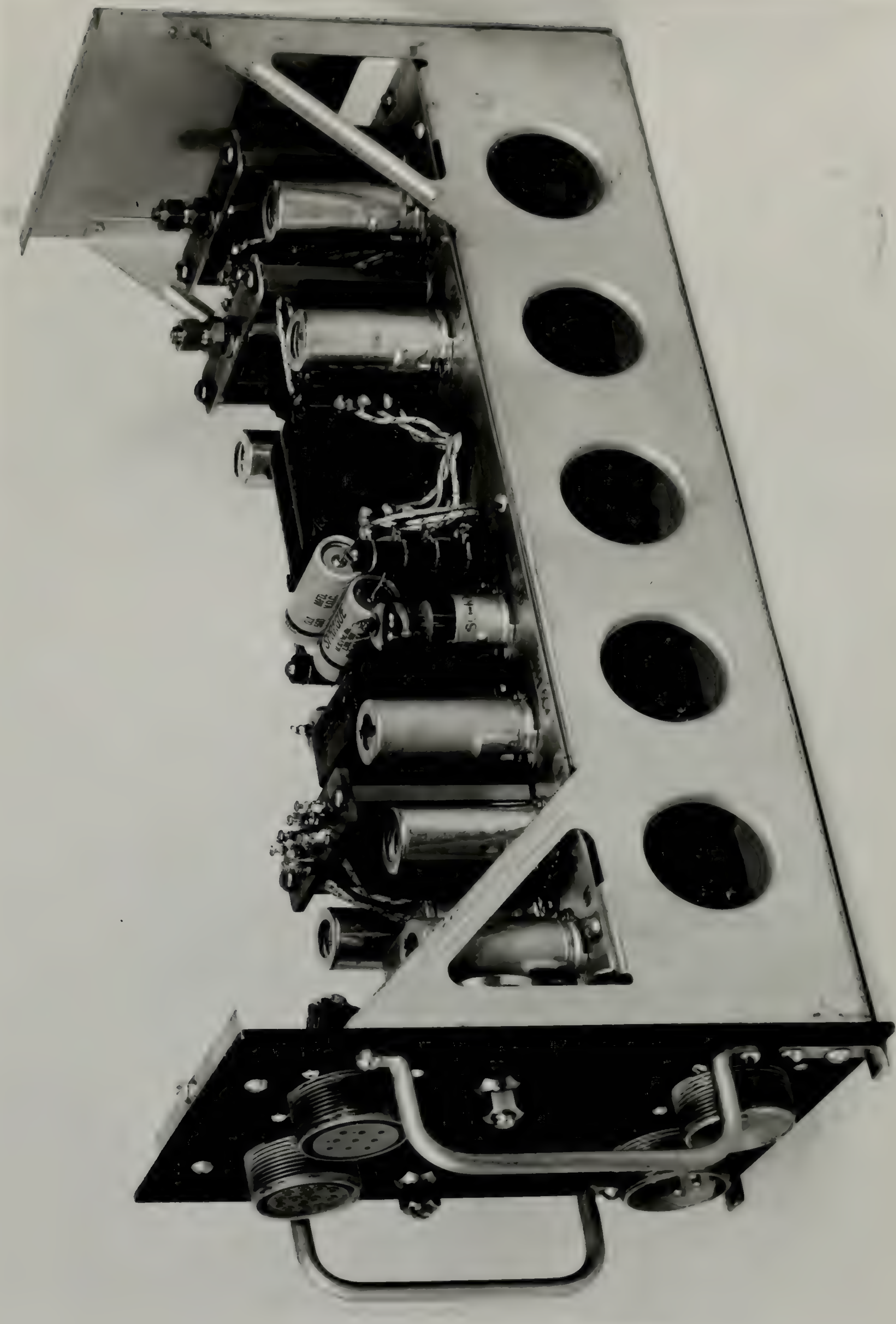


PLATE 4

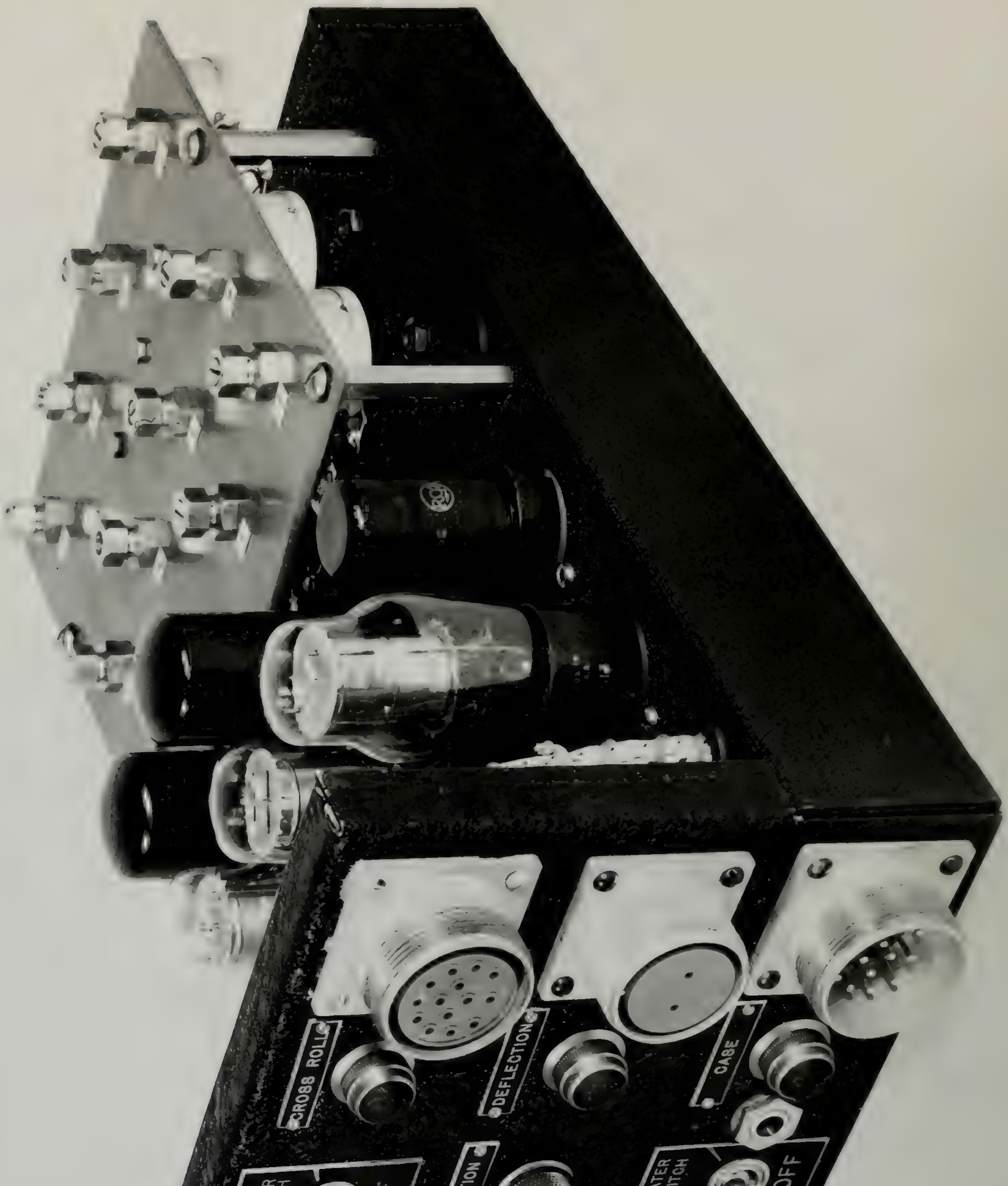

CROSS ROLL
DEFLECTION
CASE
SIGHT MASTER SWITCH
OFF
ELEVATION
HEATER SWITCH
OFF
OFF
OFF

PLATE 5

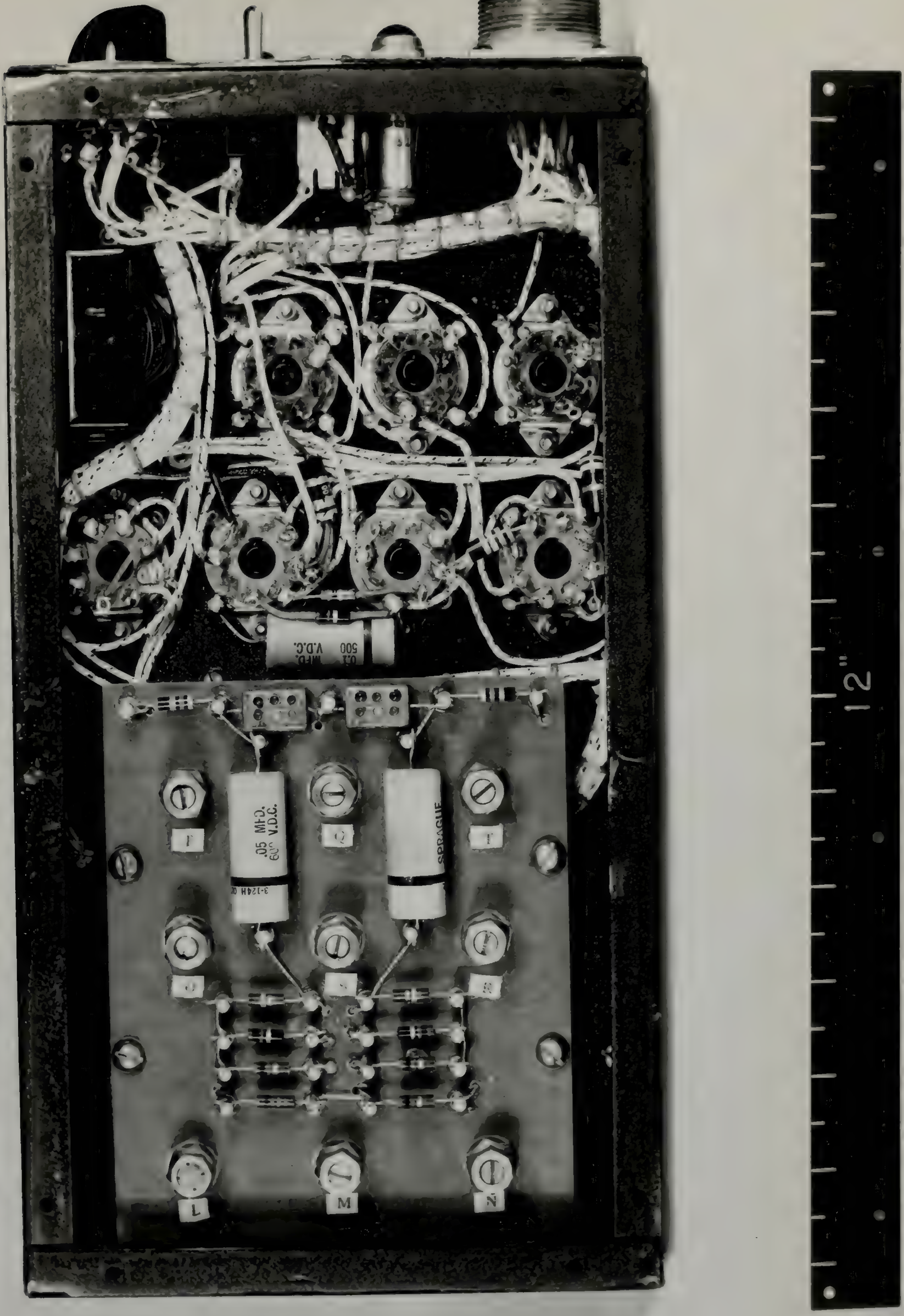


PLATE 6

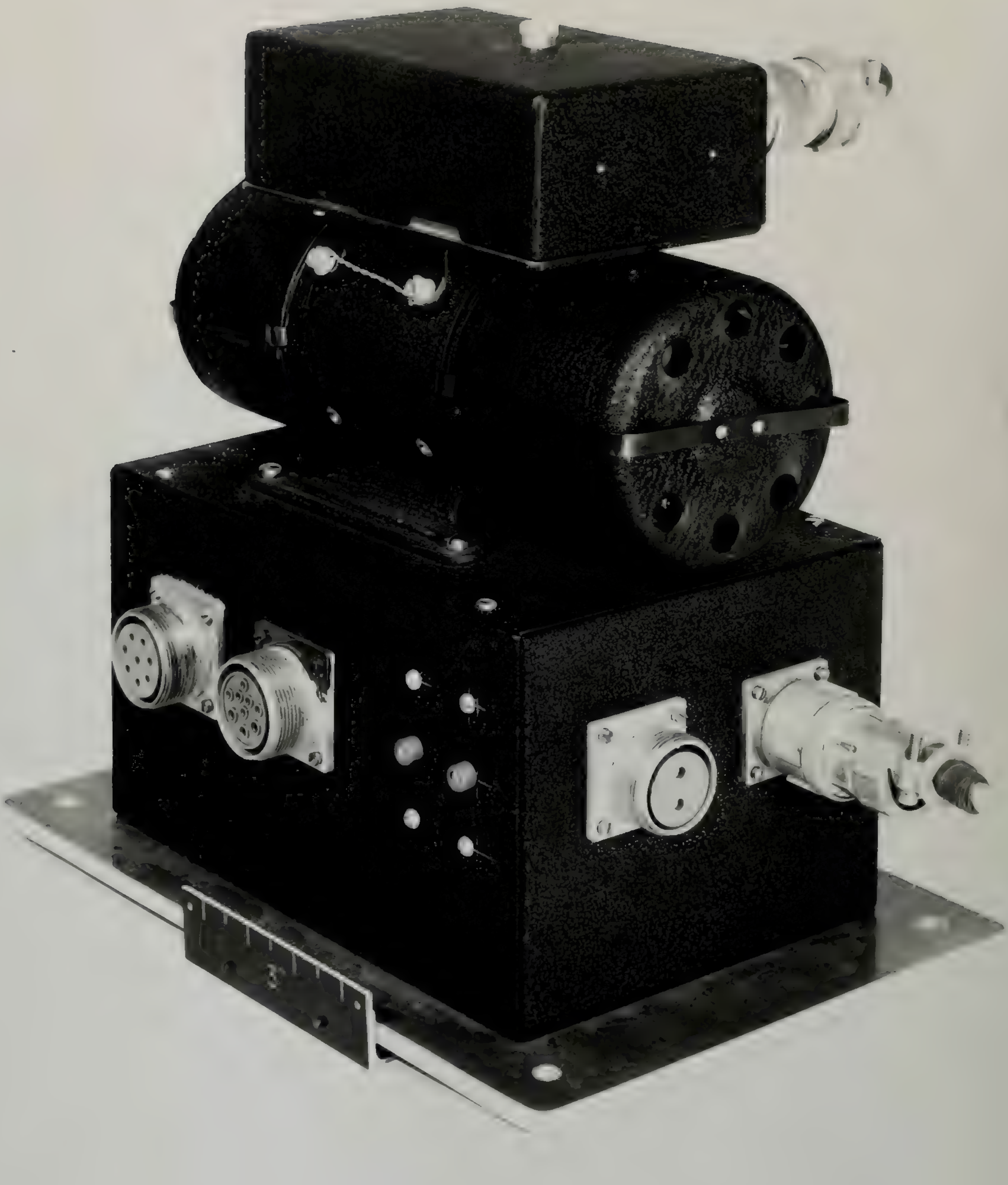


PLATE 7

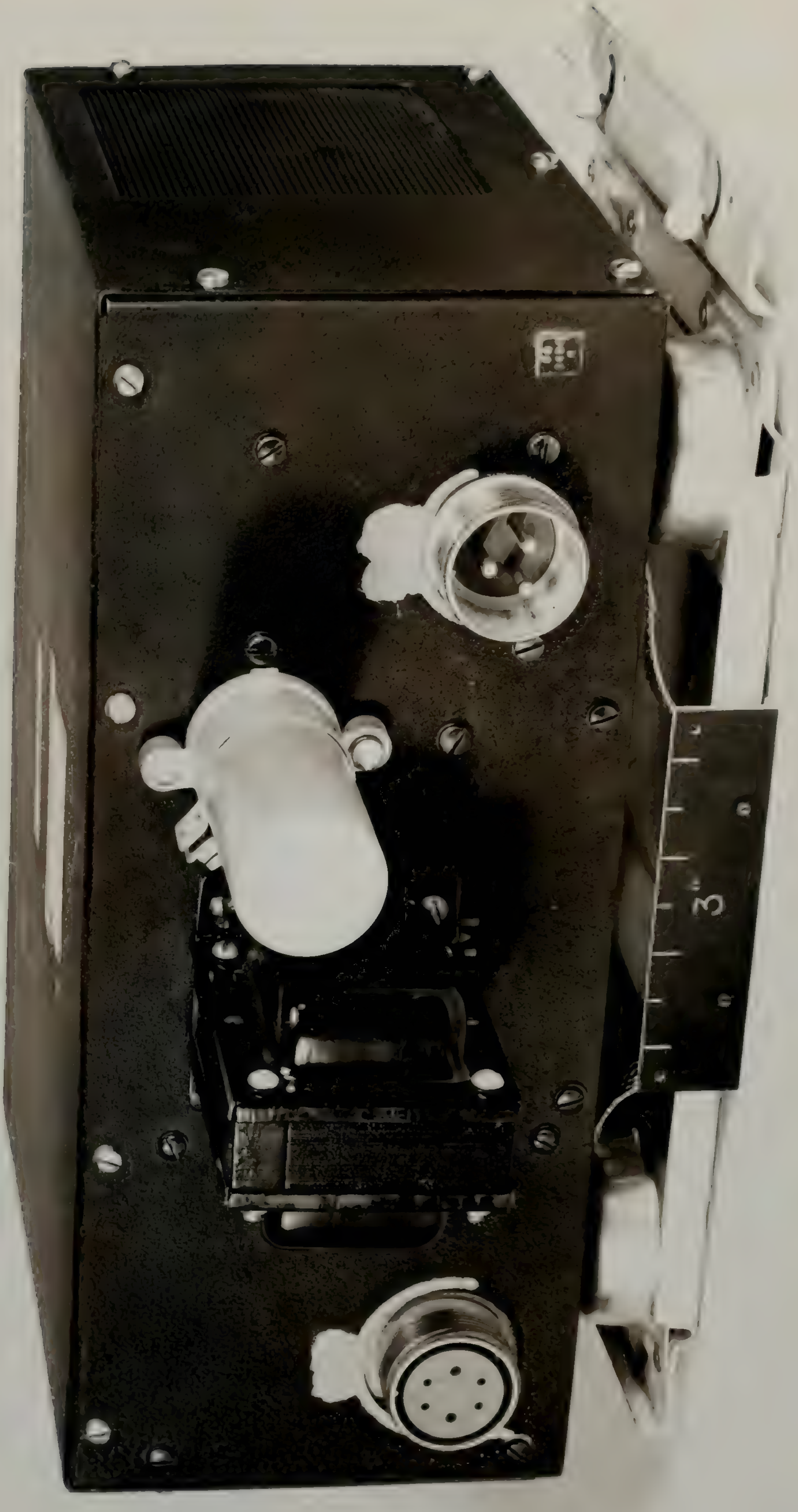


PLATE 8

PLATE 9

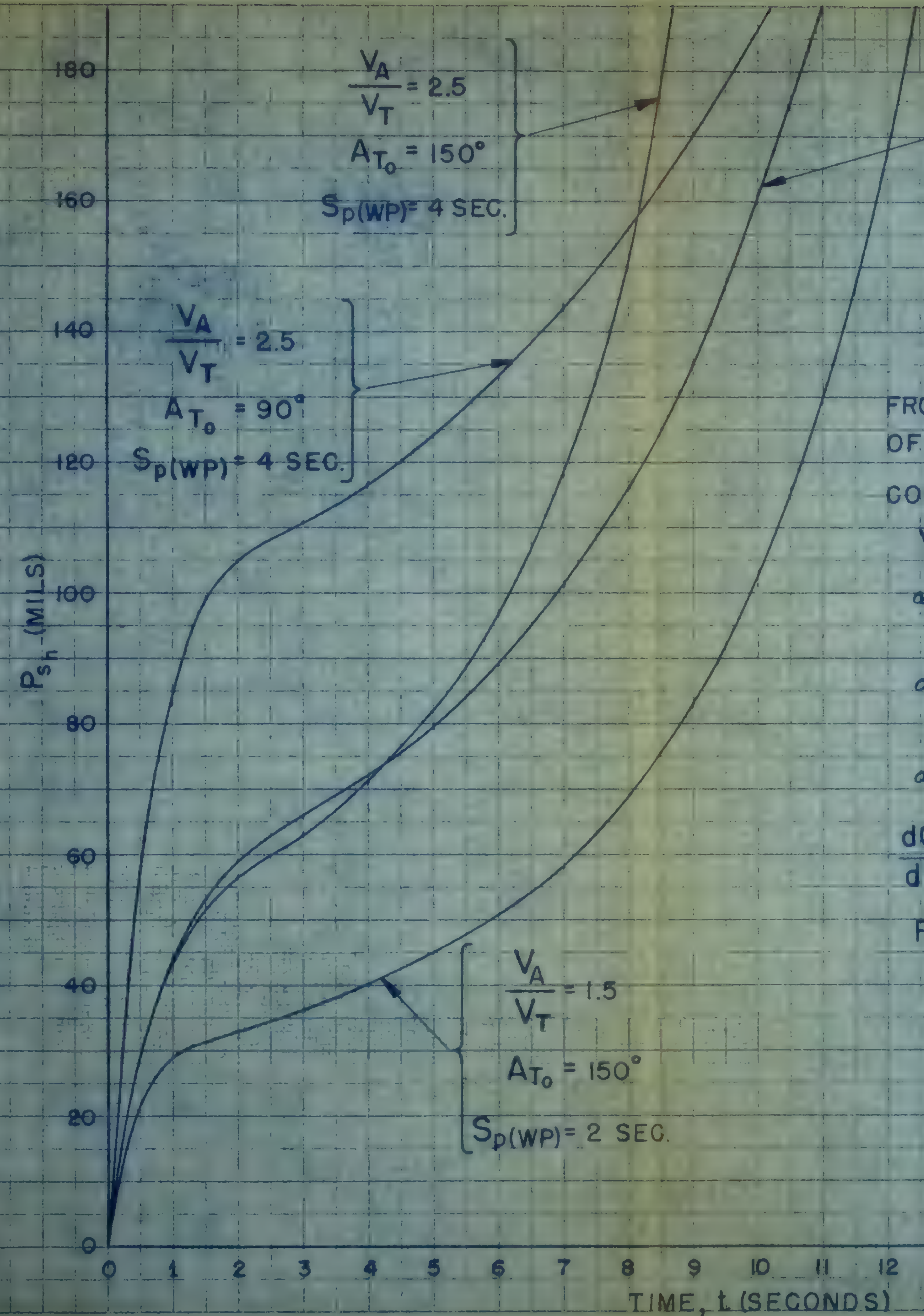
PLATE 10

APPENDIX II

FIGURES

All figures are plots of predicted lead angles as a function of time.

(ψ Also includes Tracking Inaccuracy)



ANGULAR LEAD IN HORIZONTAL PLANE (P_{s_h}) VERSUS TIME

FROM ROCKEFELLER DIFFERENTIAL ANALYZER SOLUTION #194 OF EQUATIONS GIVEN ON PAGE 6 OF THIS REPORT.

CONSTANTS IN THE EQUATIONS WERE TAKEN AS FOLLOWS:

V_A = 250 OR 150 KTS.; V_T = 100 KTS.

α_{h_0} = 12.5 MILS FOR A_{T_0} = 150° AND $\frac{V_A}{V_T} = 2.5$

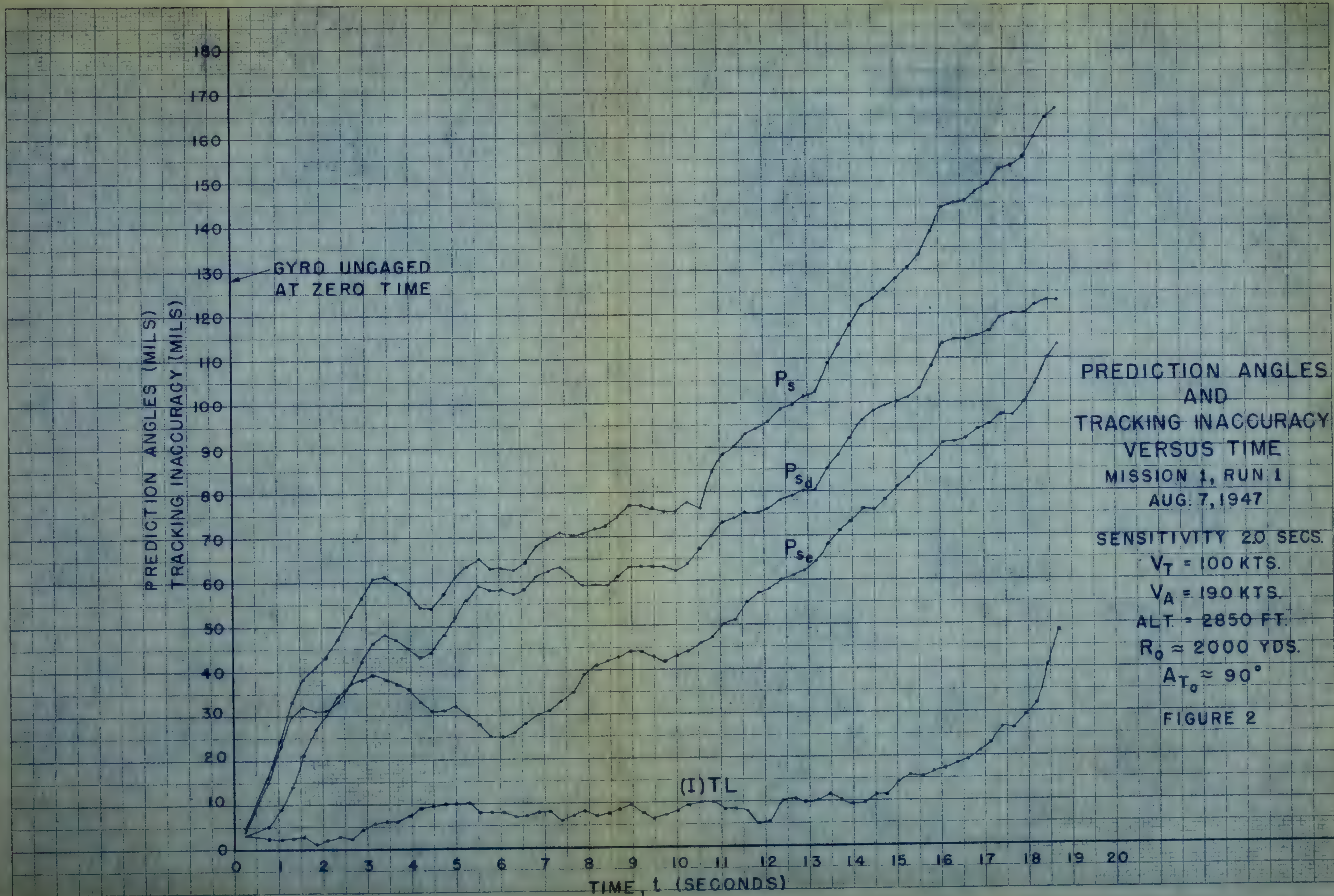
α_{h_0} = 21 MILS FOR A_{T_0} = 150° AND $\frac{V_A}{V_T} = 1.5$

α_{h_0} = 25 MILS FOR A_{T_0} = 90° AND $\frac{V_A}{V_T} = 2.5$

$\frac{dC_L}{d\alpha} = 5$; $\frac{W_A}{S} = 50$ #/SQ. FT.; $\rho_{10,000}$ = .00176 SLUGS/CU. FT.

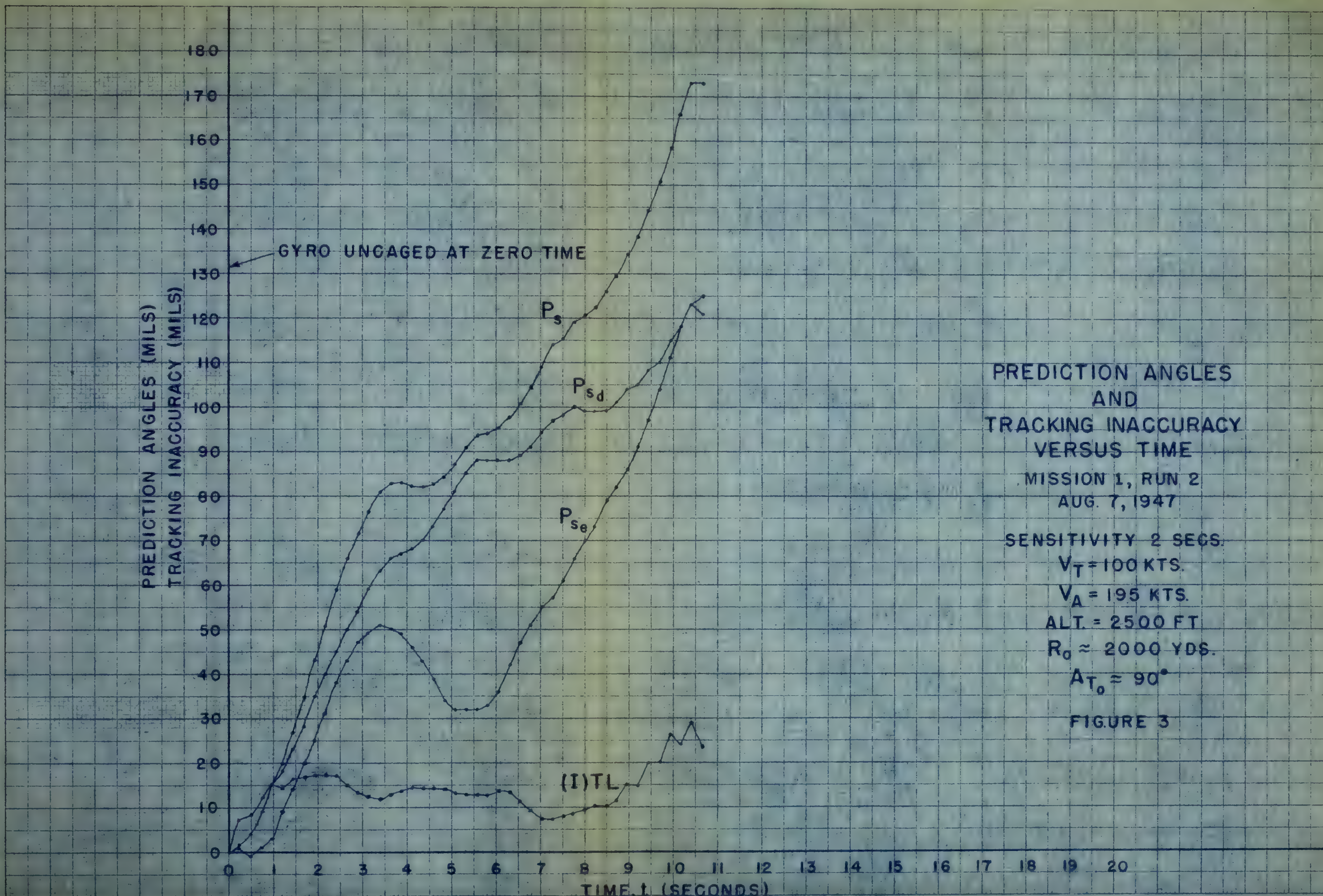
R_0 = 2000 YDS.

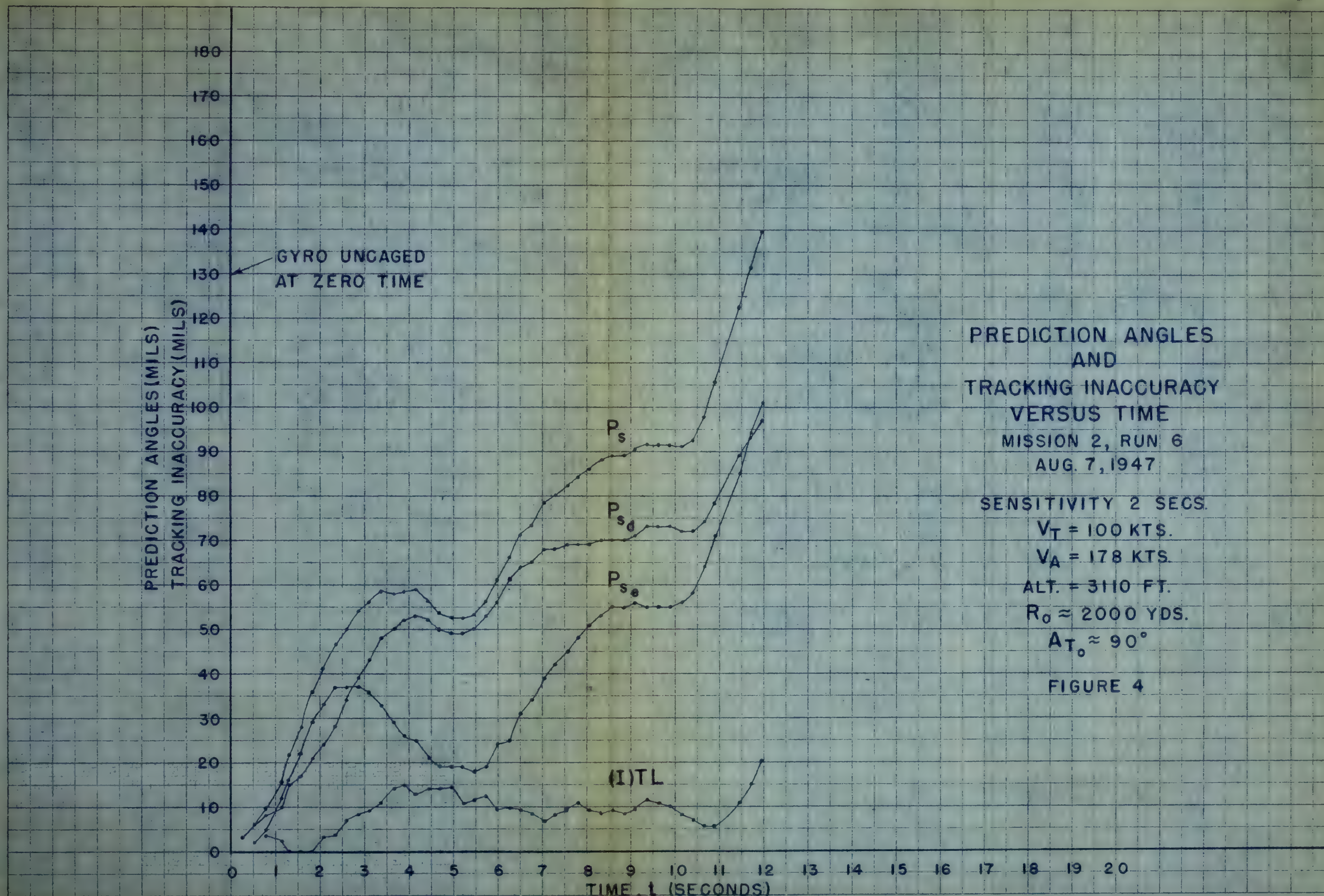
FIGURE 1

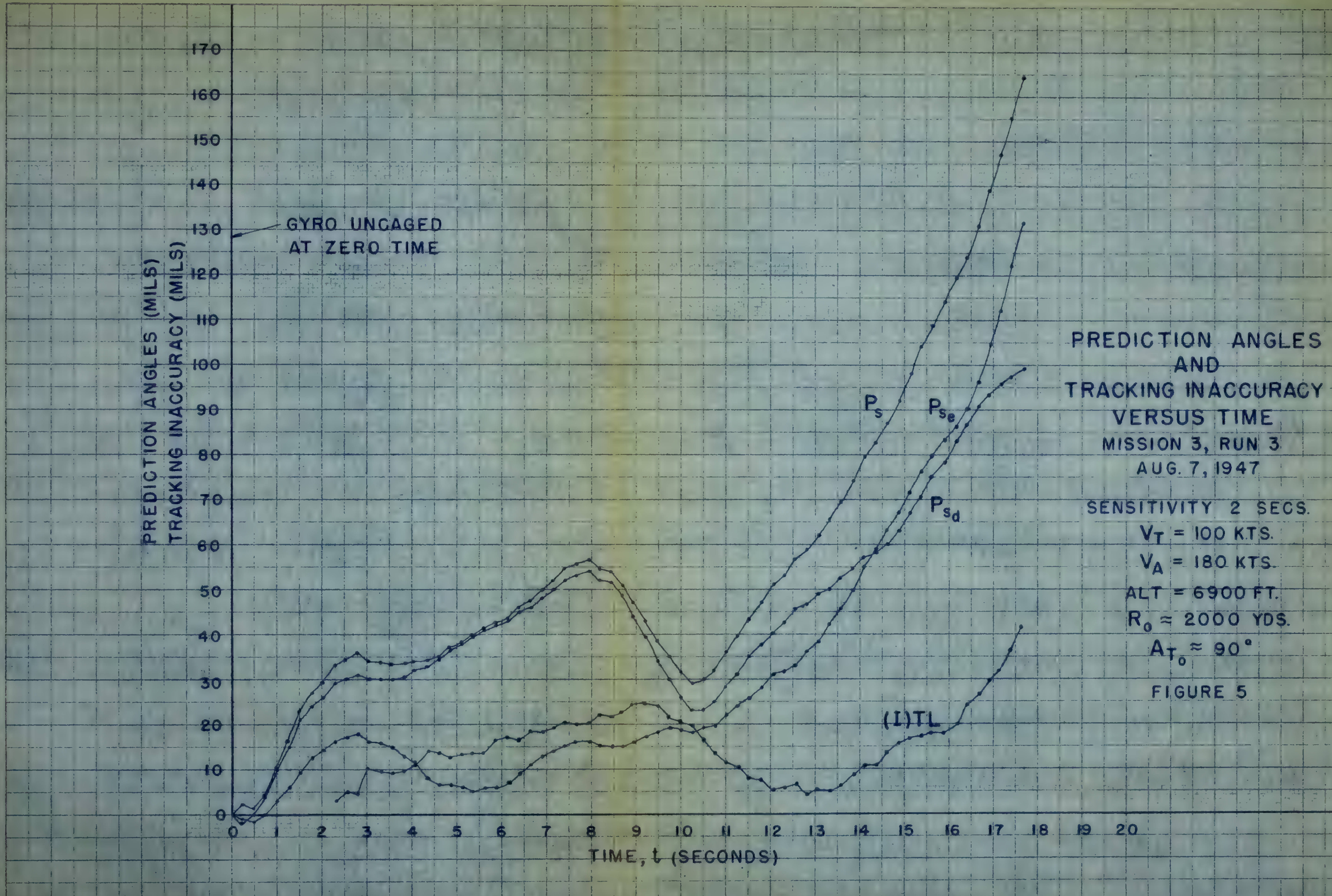


GYRO UNGAGED
AT ZERO TIME
PREDICTION ANGLES (MILS)
TRACKING INACCURACY (MILS)
P_s
P_{s_d}
P_{s_e}
(I)TL
TIME, t (SECONDS)
PREDICTION ANGLES
AND
TRACKING INACCURACY
VERSUS TIME
MISSION 1, RUN 1
AUG. 7, 1947
SENSITIVITY 2.0 SECS.
V_T = 100 KTS.
V_A = 190 KTS.
ALT. = 2850 FT.
$R_0 \approx$ 2000 YDS.
$A_{T_0} \approx 90°$

FIGURE 2

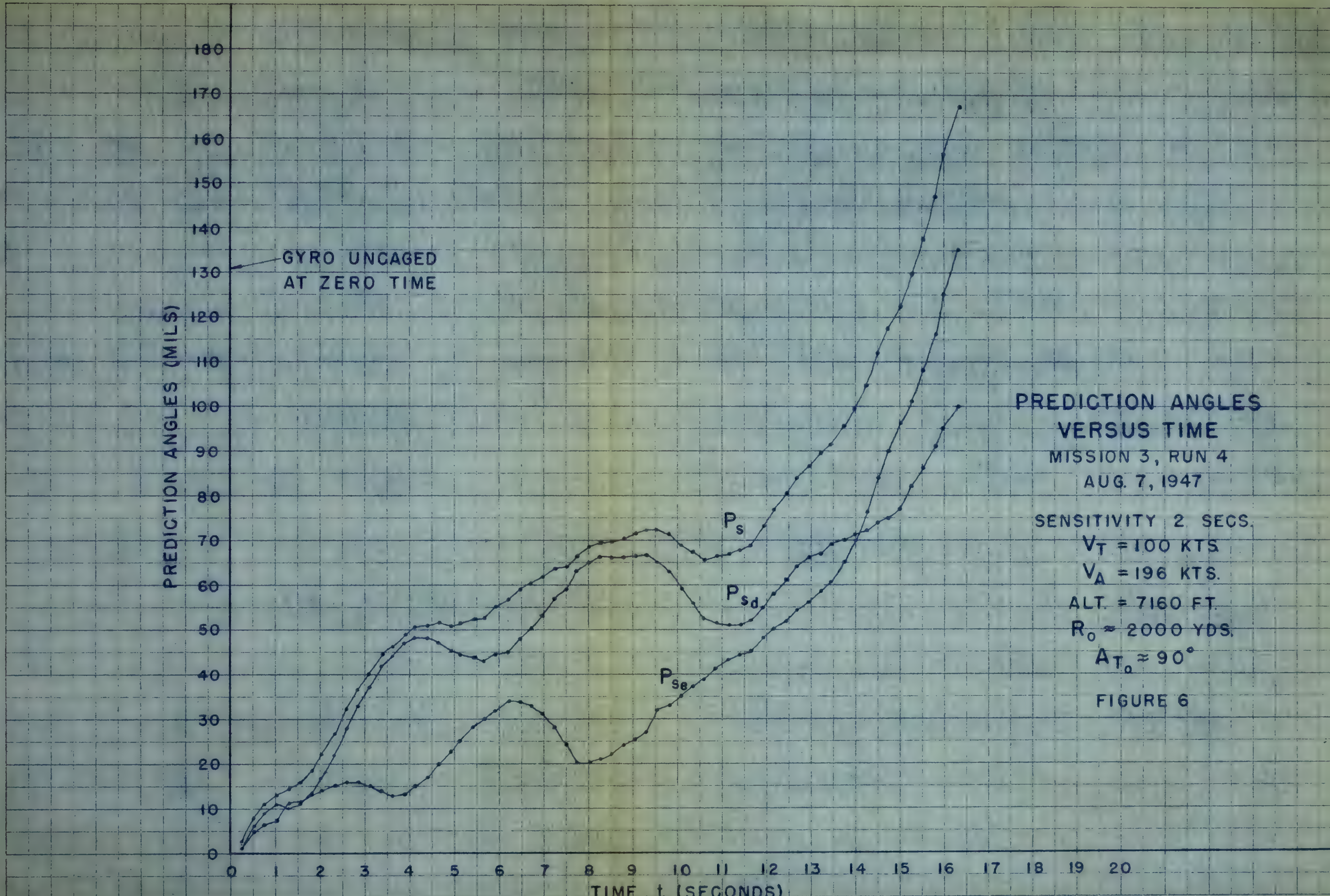

PREDICTION ANGLES
AND
TRACKING INACCURACY
VERSUS TIME
MISSION 1, RUN 2
AUG. 7, 1947
SENSITIVITY 2 SECS.
V_T = 100 KTS.
V_A = 195 KTS.
ALT. = 2500 FT.
$R_0 \approx$ 2000 YDS.
$A_{T_0} \approx 90°$
GYRO UNCAGED AT ZERO TIME
PREDICTION ANGLES (MILS)
TRACKING INACCURACY (MILS)
TIME, t (SECONDS)
P_s
P_{s_d}
P_{s_e}
(I)TL
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
FIGURE 3

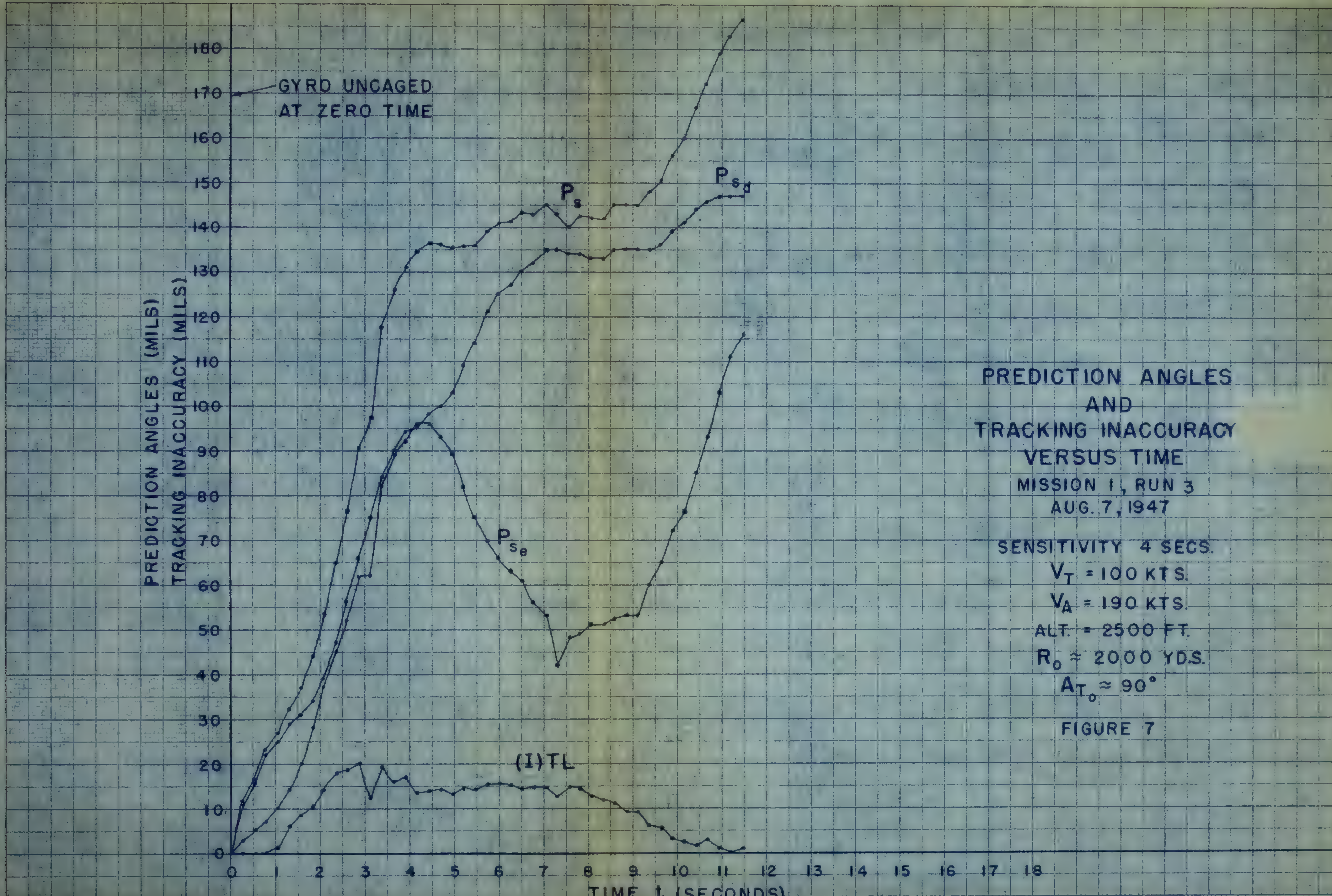

PREDICTION ANGLES AND TRACKING INACCURACY VERSUS TIME
MISSION 2, RUN 6
AUG. 7, 1947
SENSITIVITY 2 SECS.
V_T = 100 KTS.
V_A = 178 KTS.
ALT. = 3110 FT.
$R_o \approx$ 2000 YDS.
$A_{T_o} \approx 90°$
GYRO UNCAGED AT ZERO TIME
PREDICTION ANGLES (MILS)
TRACKING INACCURACY (MILS)
TIME, t (SECONDS)
P_s
P_{s_d}
P_{s_e}
(I)TL
FIGURE 4



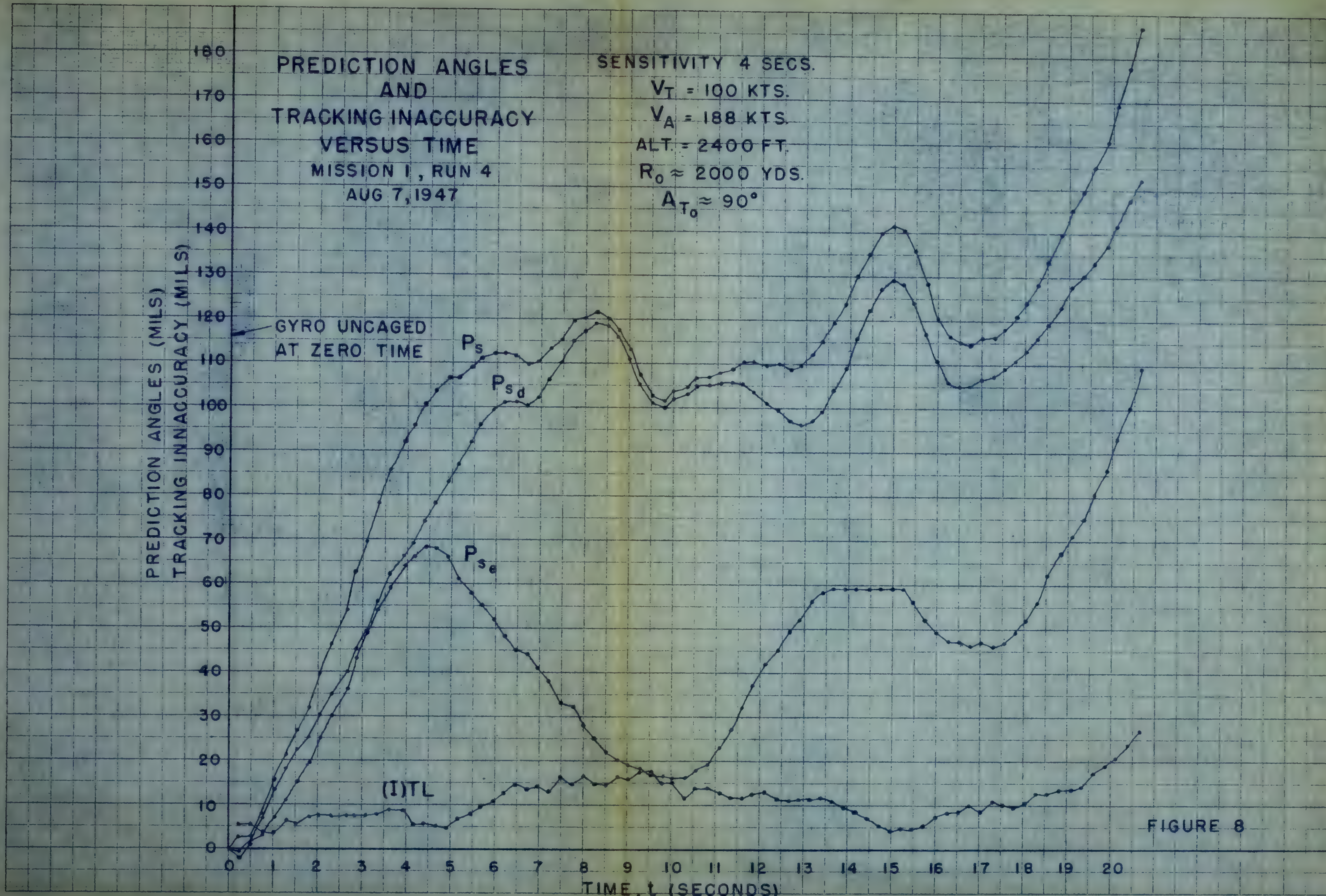
GYRO UNCAGED AT ZERO TIME
PREDICTION ANGLES (MILS)
TRACKING INACCURACY (MILS)
TIME, t (SECONDS)
P_s
P_{s_e}
P_{s_d}
(I)TL
PREDICTION ANGLES AND TRACKING INACCURACY VERSUS TIME
MISSION 3, RUN 3
AUG. 7, 1947
SENSITIVITY 2 SECS.
V_T = 100 KTS.
V_A = 180 KTS.
ALT = 6900 FT.
$R_0 \approx$ 2000 YDS.
$A_{T_0} \approx 90°$

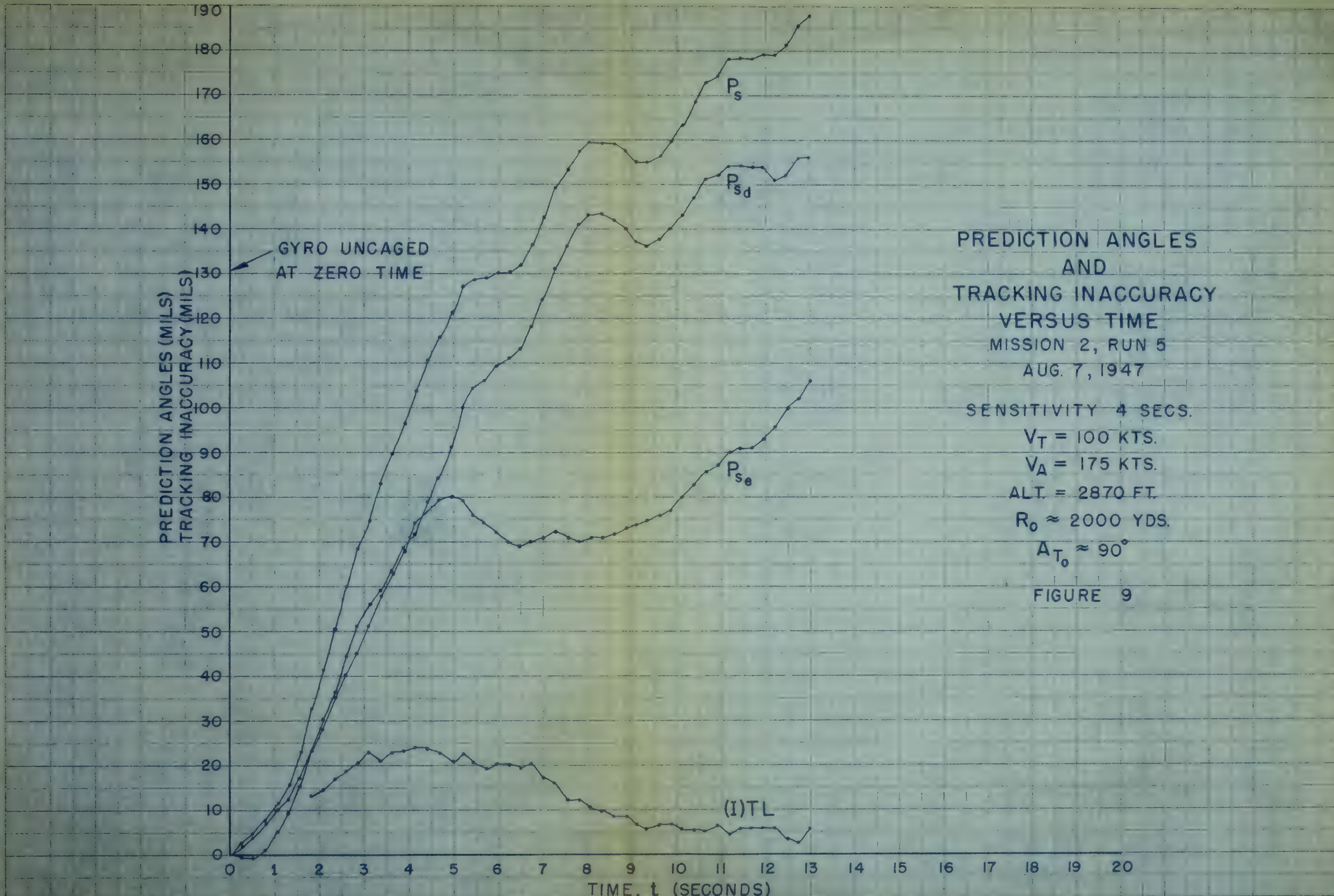
FIGURE 5


PREDICTION ANGLES
VERSUS TIME
MISSION 3, RUN 4
AUG. 7, 1947
SENSITIVITY 2 SECS.
V_T = 100 KTS.
V_A = 196 KTS.
ALT. = 7160 FT.
$R_0 \approx$ 2000 YDS.
$A_{T_0} \approx 90°$
GYRO UNCAGED
AT ZERO TIME
P_s
P_{s_d}
P_{s_e}
PREDICTION ANGLES (MILS)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
TIME, t (SECONDS)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
FIGURE 6



PREDICTION ANGLES (MILS)
TRACKING INACCURACY (MILS)
TIME, t (SECONDS)
GYRO UNCAGED AT ZERO TIME
P_s
P_{s_d}
P_{s_e}
(I)TL
PREDICTION ANGLES AND TRACKING INACCURACY VERSUS TIME
MISSION 1, RUN 3
AUG. 7, 1947
SENSITIVITY 4 SECS.
V_T = 100 KTS.
V_A = 190 KTS.
ALT. = 2500 FT.
$R_0 \approx$ 2000 YDS.
$A_{T_0} \approx 90°$
FIGURE 7

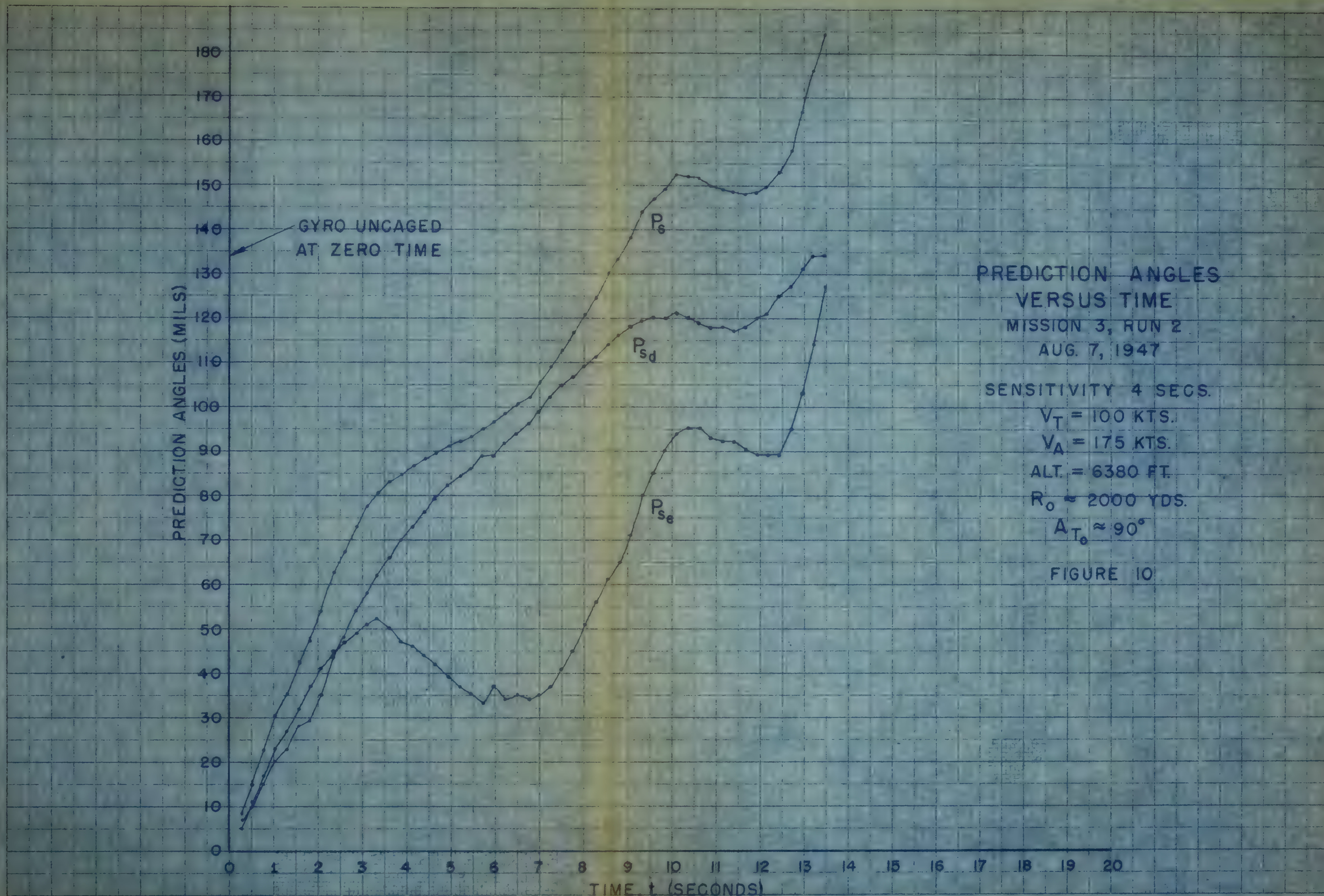

PREDICTION ANGLES
AND
TRACKING INACCURACY
VERSUS TIME
MISSION I, RUN 4
AUG 7, 1947
SENSITIVITY 4 SECS.
V_T = 100 KTS.
V_A = 188 KTS.
ALT. = 2400 FT.
$R_0 \approx$ 2000 YDS.
$A_{T_0} \approx 90°$
GYRO UNCAGED
AT ZERO TIME
P_s
P_{s_d}
P_{s_e}
(I)TL
PREDICTION ANGLES (MILS)
TRACKING INNACCURACY (MILS)
TIME, t (SECONDS)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
FIGURE 8

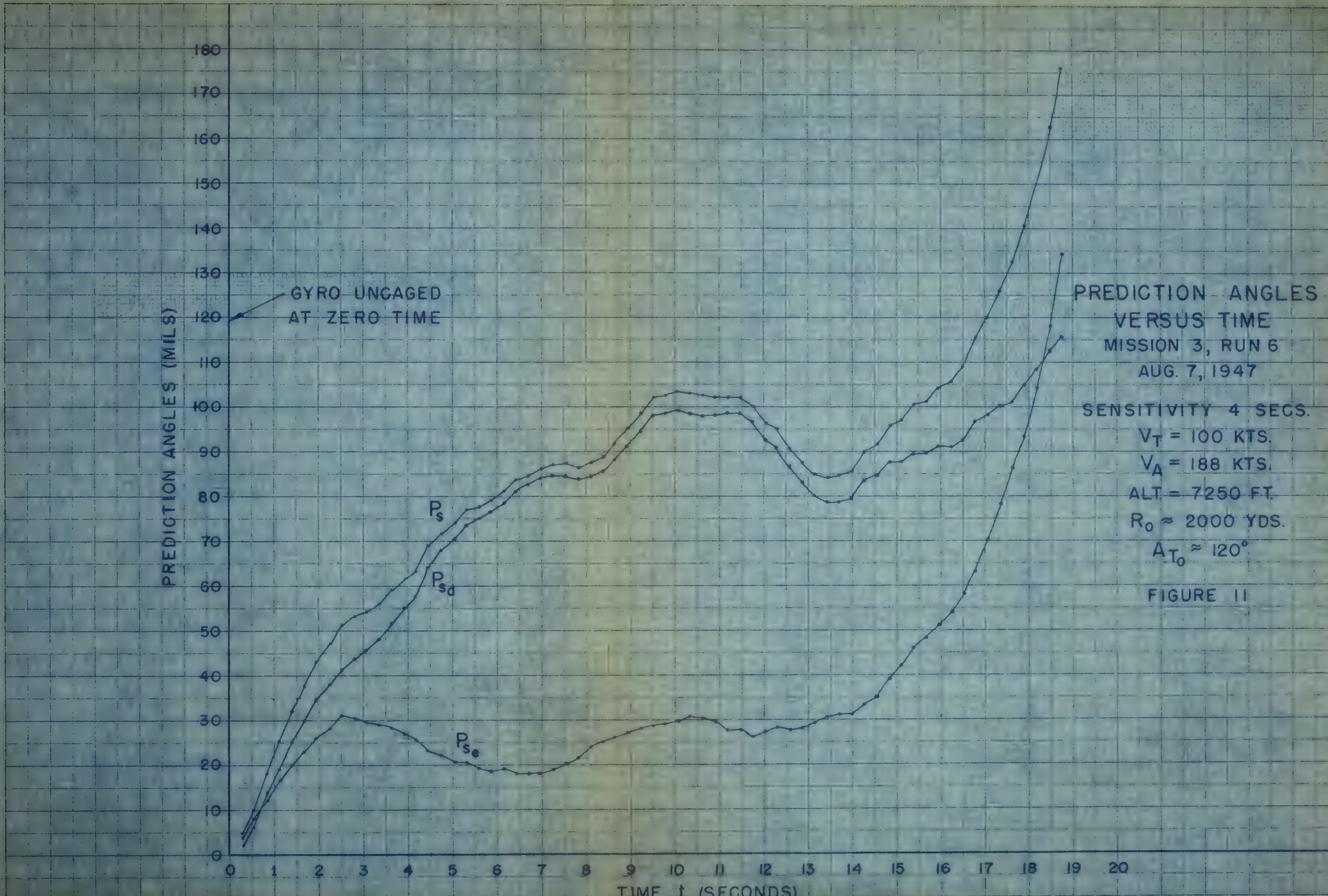


PREDICTION ANGLES
AND
TRACKING INACCURACY
VERSUS TIME
MISSION 2, RUN 5
AUG. 7, 1947

SENSITIVITY 4 SECS.
V_T = 100 KTS.
V_A = 175 KTS.
ALT. = 2870 FT.
$R_0 \approx$ 2000 YDS.
$A_{T_0} \approx 90°$

FIGURE 9


GYRO UNCAGED AT ZERO TIME
PREDICTION ANGLES (MILS)
TIME, t (SECONDS)
P_s
P_{s_d}
P_{s_e}
PREDICTION ANGLES VERSUS TIME
MISSION 3, RUN 2
AUG. 7, 1947
SENSITIVITY 4 SECS.
V_T = 100 KTS.
V_A = 175 KTS.
ALT. = 6380 FT.
$R_o \approx$ 2000 YDS.
$A_{T_o} \approx 90°$
KEUFFEL & ESSER CO. N.Y.
FIGURE 10



PREDICTION ANGLES
VERSUS TIME
MISSION 3, RUN 6
AUG. 7, 1947

SENSITIVITY 4 SECS.

V_T = 100 KTS.

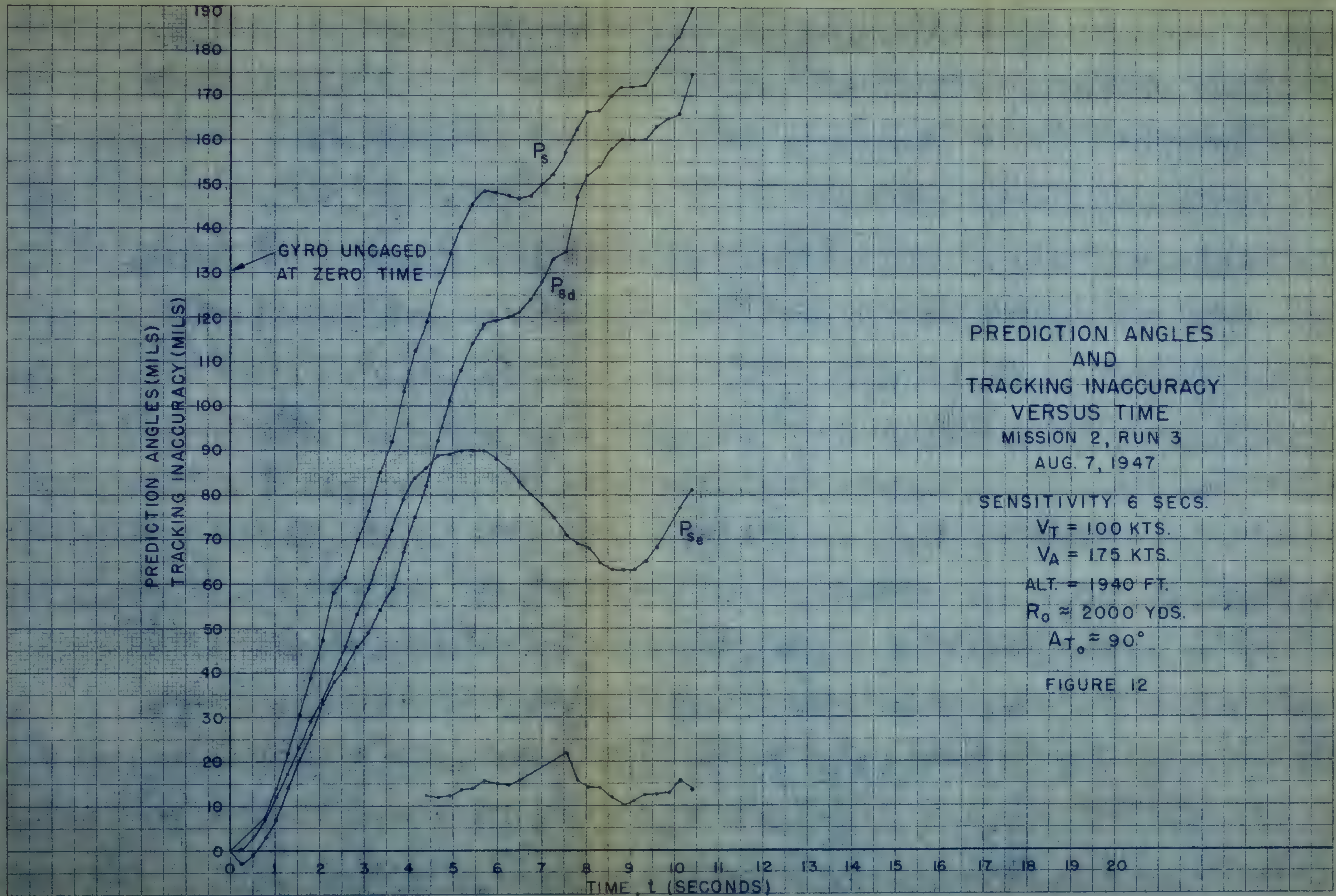
V_A = 188 KTS.

ALT. = 7250 FT.

$R_0 \approx$ 2000 YDS.

$A_{T_0} \approx 120°$

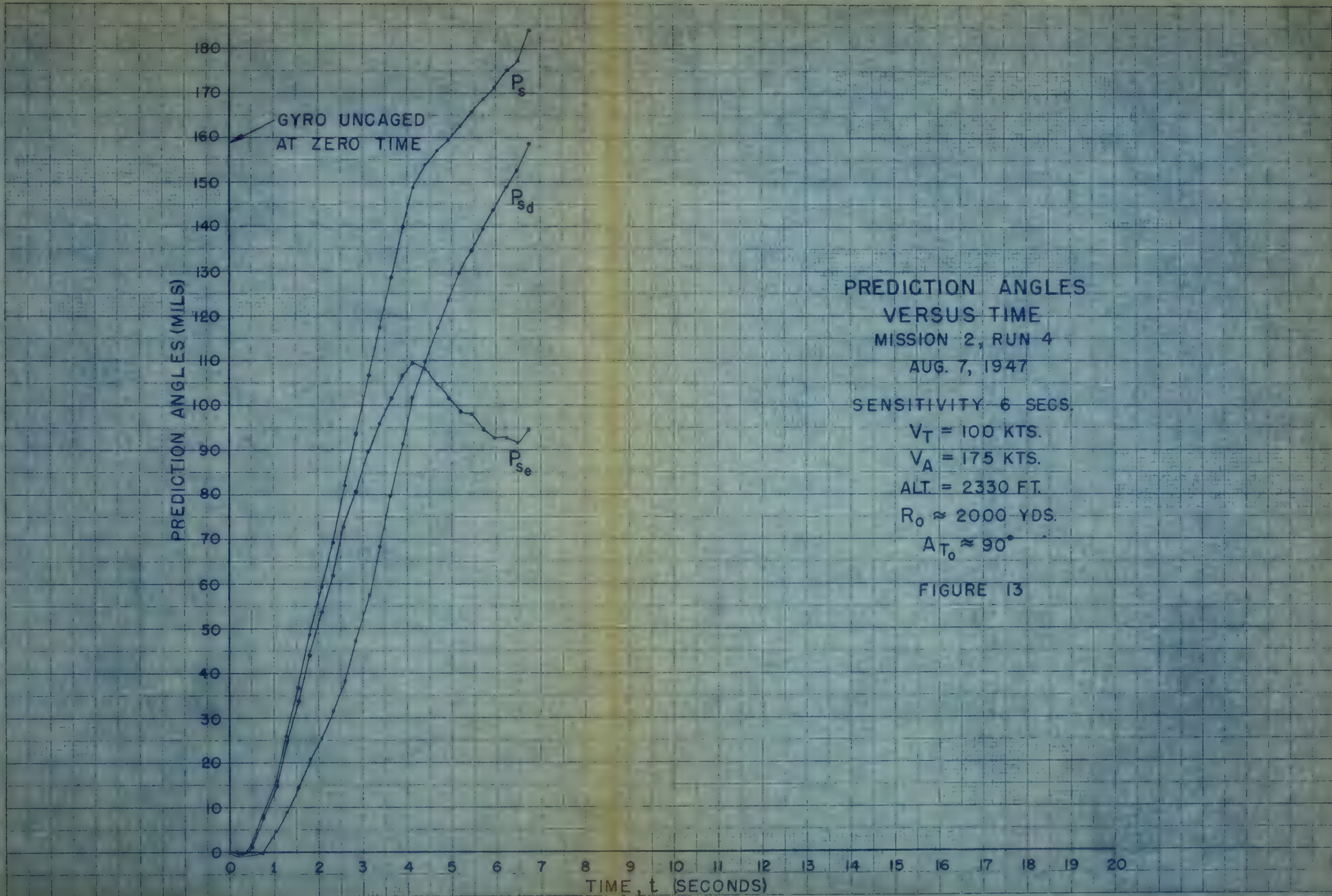
FIGURE 11

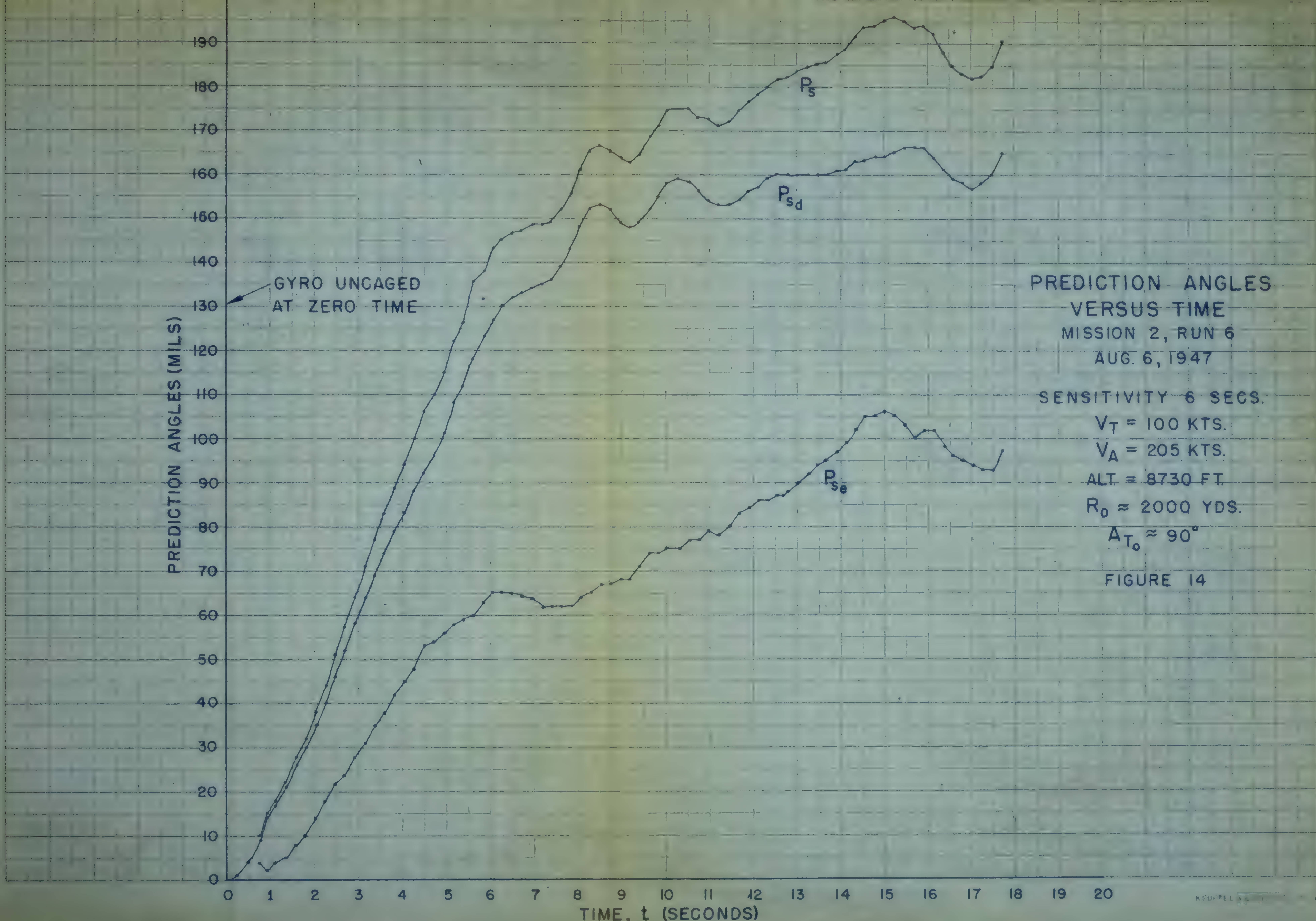


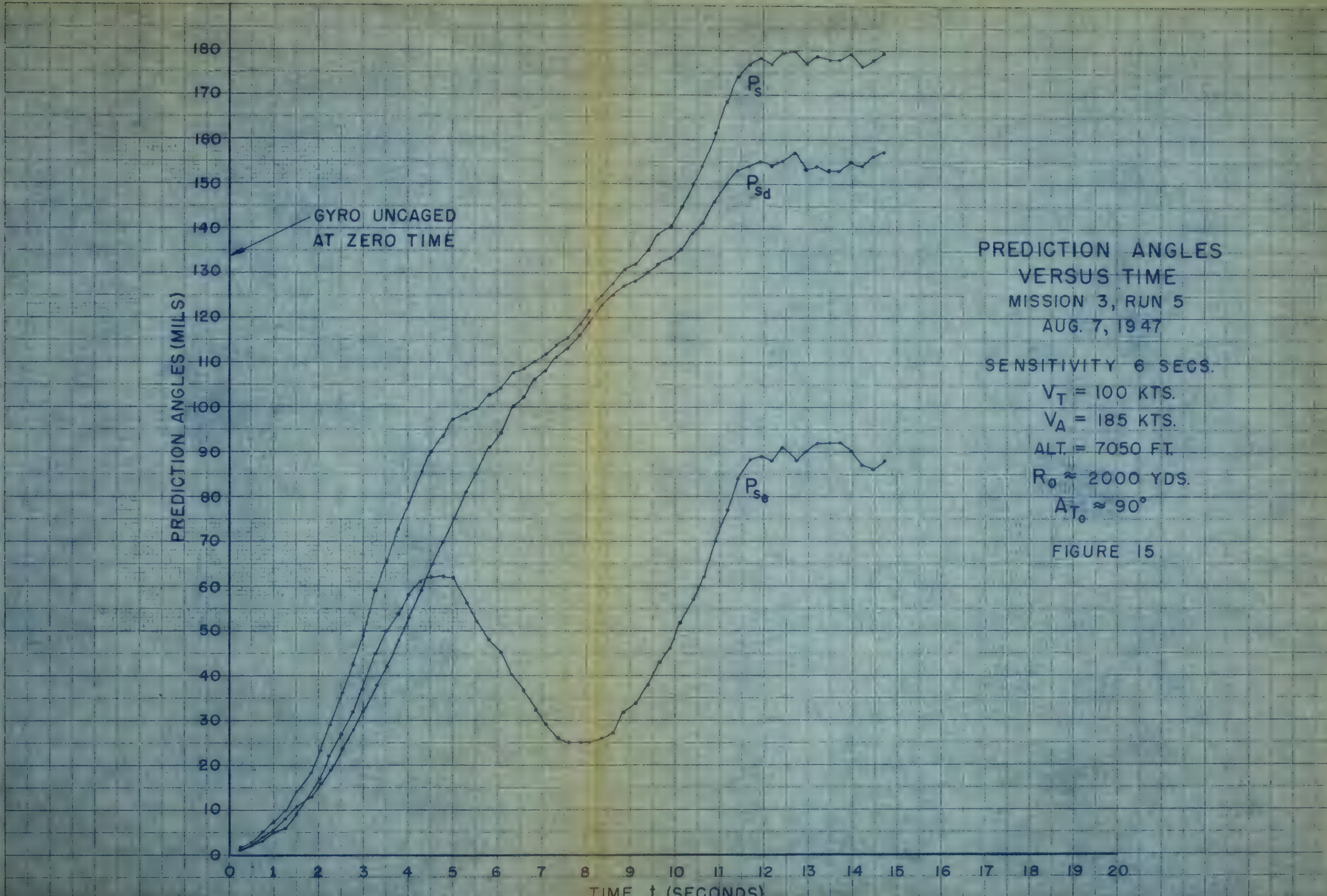
PREDICTION ANGLES
AND
TRACKING INACCURACY
VERSUS TIME
MISSION 2, RUN 3
AUG. 7, 1947

SENSITIVITY 6 SECS.
V_T = 100 KTS.
V_A = 175 KTS.
ALT. = 1940 FT.
$R_0 \approx$ 2000 YDS.
$A_{T_0} \approx 90°$

FIGURE 12


GYRO UNCAGED
AT ZERO TIME
PREDICTION ANGLES (MILS)
TIME, t (SECONDS)
P_s
P_{s_d}
P_{s_e}
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
PREDICTION ANGLES
VERSUS TIME
MISSION 2, RUN 4
AUG. 7, 1947
SENSITIVITY 6 SECS.
V_T = 100 KTS.
V_A = 175 KTS.
ALT. = 2330 FT.
$R_o \approx$ 2000 YDS.
$A_{T_o} \approx 90°$
FIGURE 13


PREDICTION ANGLES VERSUS TIME
MISSION 2, RUN 6
AUG. 6, 1947
SENSITIVITY 6 SECS.
V_T = 100 KTS.
V_A = 205 KTS.
ALT. = 8730 FT.
$R_0 \approx$ 2000 YDS.
$A_{T_0} \approx 90°$
GYRO UNCAGED AT ZERO TIME
P_s
P_{s_d}
P_{s_e}
PREDICTION ANGLES (MILS)
TIME, t (SECONDS)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
FIGURE 14



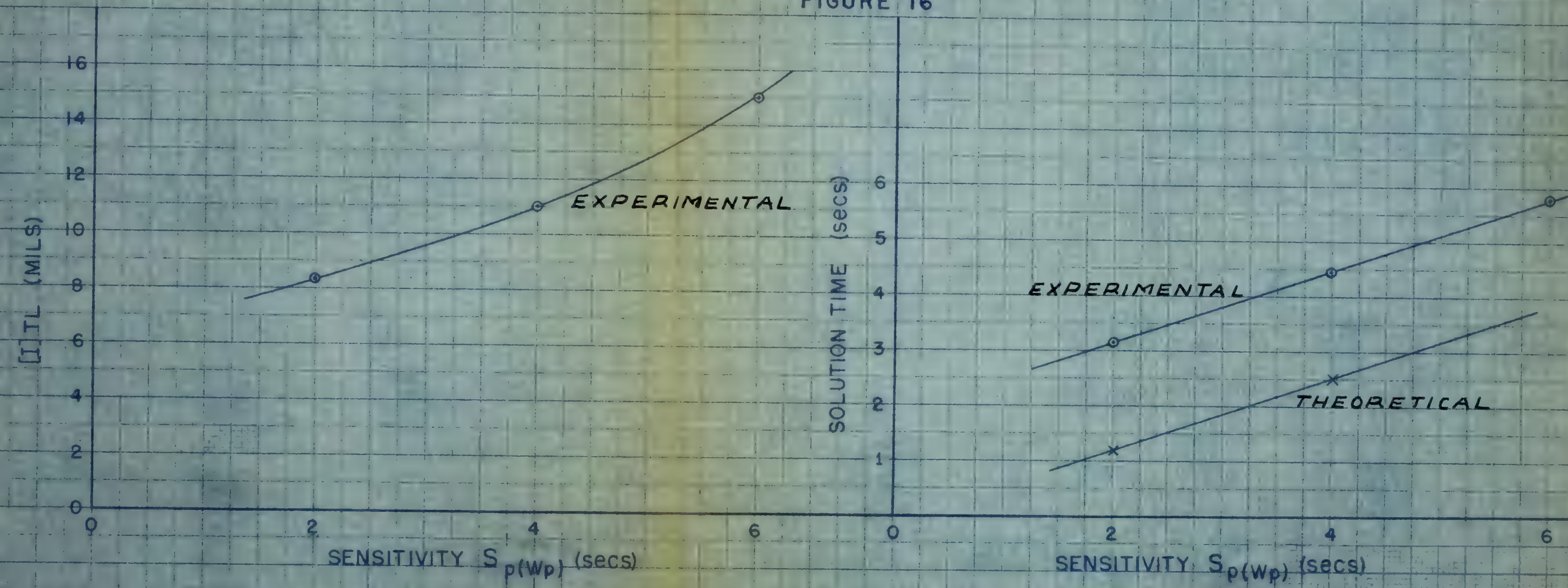
PREDICTION ANGLES VERSUS TIME
MISSION 3, RUN 5
AUG. 7, 1947

SENSITIVITY 6 SECS.
V_T = 100 KTS.
V_A = 185 KTS.
ALT. = 7050 FT.
$R_0 \approx$ 2000 YDS.
$A_{T_0} \approx 90°$

FIGURE 15

TRACKING INACCURACY AND
SOLUTION TIME AS A FUNCTION
OF STATIC SENSITIVITY

FIGURE 16



APPENDIX III

LIST OF PLATES

PLATE 1

PLATE 2

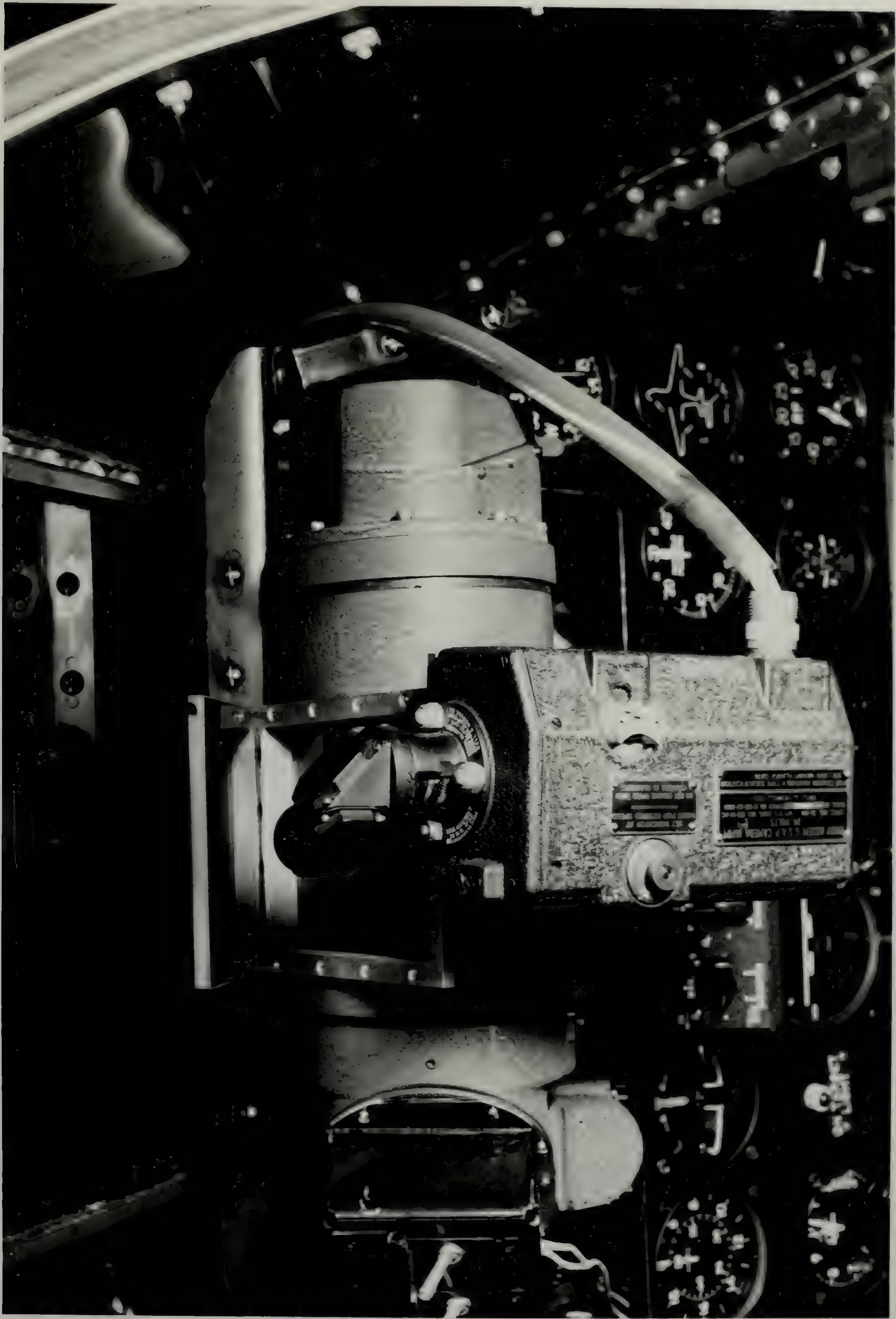


PLATE 3

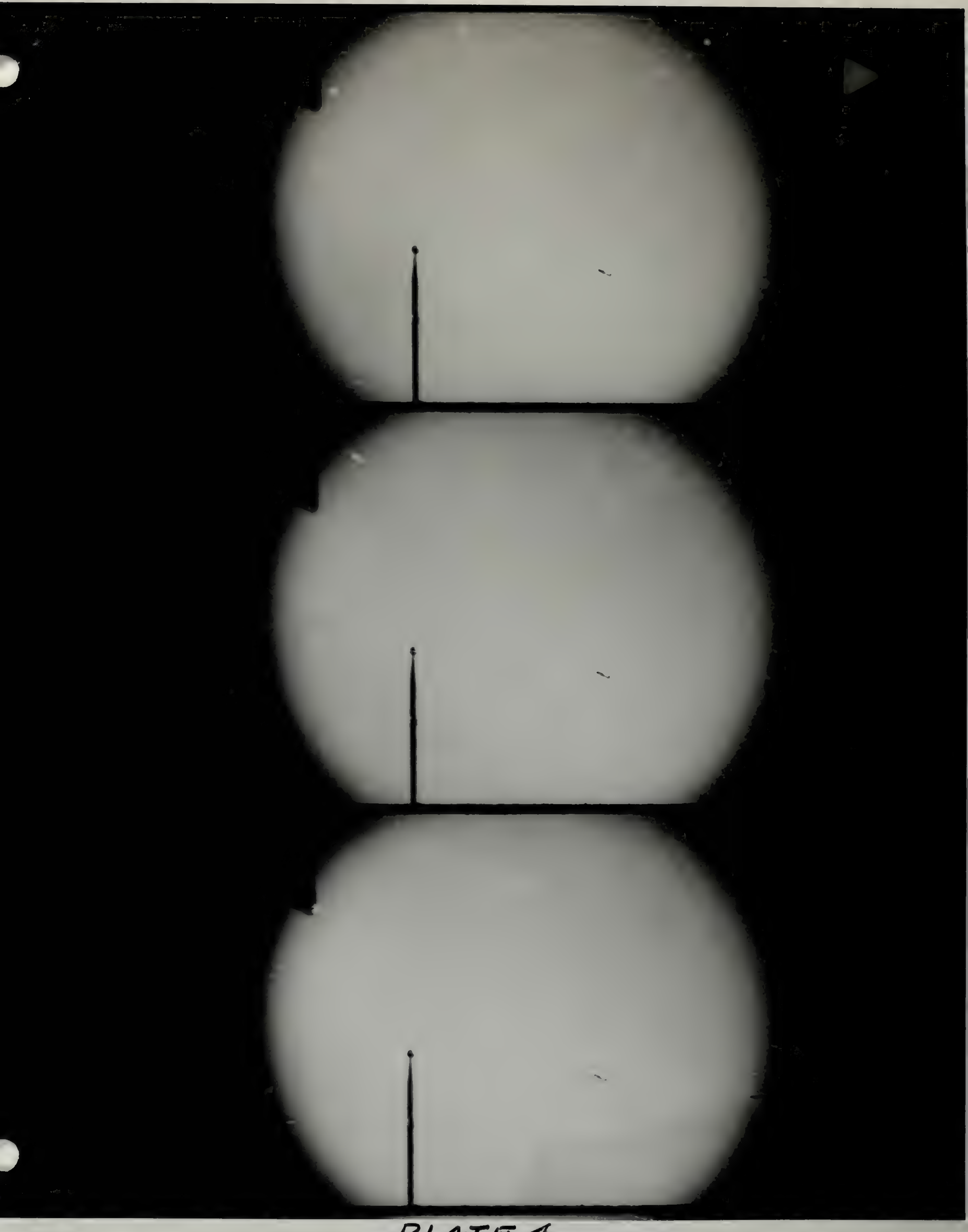


PLATE 4

PLATE 5

APPENDIX IV

DATA

Mission No.	Run Number	Pages
1	1	1-2
1	2	3-4
2	6	5-6
3	3	7-8
3	4	9-10
1	3	11-12
1	4	13-15
2	5	16-17
3	2	18-19
3	6	20-21
2	3	22-23
2	4	24
2	6	25-27
3	5	28-29

Mission # 1 Run # 1 $S_{[WP]} = 2$ sec.
August 7, 1977 Page # 1

Frame	t_{corr}	Te	Re	Td	Rd	Psa	Psd	Ps	[I]TLe	[I]TLd	[I]TL	Clock Time	Va	Accel.	Altitude
–	sec.	mils	mils	mils	mils	mils	mils	mils	mils	mils	mils	sec.	knots	g's	Ft.
1		111.5	101	289	295	0	0	–	-10	6	11.5	3.3	195	1.1	2850
5	0	108	101	290	294	0	1	1.0	-7	4	8.05	3.6	195	1.4	
9	.26	101	104	290	291	3	4	5	3	1	3.16	3.9	195	1.2	
13	.53	–	–	–	–	–	–	–	–	–	–	–	–	–	
17	.79	107	106	282	280	5	15	15.8	-1	-2	2.24	4.2	190	1.2	
21	1.05	111	110	270	272	9	23	24.6	-1	2	2.24	4.6			
25	1.32	116	115	263	265	14	30	83.0	-1	2	2.24	4.8			
29	1.58	124	122	261	263	21	32	38.3	-2	2	2.8	5.0			
33	1.85	128	128	265	264	27	32	41.0	0	-1	1.0	5.2			
37	2.11	131	131	266	264	30	31	43.2	0	-2	2.0	5.5			
41	2.37	137	135	264	262	34	33	47.4	-2	-2	2.8	5.8			
45	2.64	140	138	259	258	37	37	52.4	-2	-1	2.24	6.0			
49	2.90	143	139	252	253	38	42	56.7	-4	1	4.1	6.2			
53	3.17	145	140	247	249	39	46	60.3	-5	2	5.4	6.5			
57	3.43	145	139	245	247	38	48	61.2	-6	2	6.3	6.8			2830
61	3.69	144	138	247	248	37	47	59.7	-6	1	6.0	7.0			2820
65	3.96	144	137	252	250	36	45	57.6	-7	-2	7.3	7.2			
69	4.22	142	134	256	252	33	43	54.1	-8	-4	8.9	7.5			
73	4.48	141	132	254	251	31	44	53.8	-9	-3	9.5	7.8			
77	4.75	142	132	248	247	31	48	57.1	-10	-1	10.0	8.1			
81	5.01	143	133	242	243	32	52	61.0	-10	1	10.0	8.3			
85	5.28	141	131	237	239	30	56	63.5	-10	2	10.1	8.6			
89	5.54	137	129	236	236	28	59	65.2	-8	0	8.0	8.9			
93	5.80	134	126	237	237	25	58	63.0	-8	0	8.0	9.1			
97	6.06	134	126	238	237	25	58	63.0	-8	-1	8.0	9.4			2810
101	6.33	134	127	238	238	26	57	62.5	-7	0	7.0	9.7			
105	6.60	136	129	235	237	28	58	64.2	-7	2	7.3	10.0			
109	6.86	138	131	230	234	30	61	68.0	-7	4	8.0	10.2			
113	7.12	139	132	229	233	31	62	69.3	-7	4	8.0	10.5			
117	7.39	140	134	231	232	33	65	71	-6	1	6.1	10.7			
121	7.65	143	136	234	234	35	61	70.2	-7	0	7.0	11.0			
125	7.91	148	140	235	236	39	59	70.7	-8	1	8.1	11.2			
129	8.18	149	142	235	236	41	59	71.8	-7	1	7.1	11.3			
133	8.44	150	143	233	286	42	59	72.4	-7	3	7.6	11.5			
137	8.70	152	144	231	234	43	61	74.7	-8	3	8.5	11.6			
141	8.96	154	145	229	232	44	65	76.9	-9	3	9.5	11.8			
145	9.23	152	145	229	232	44	63	70.9	-7	3	7.6	12.0			
149	9.49	150	144	231	232	43	63	70.1	-6	1	6.1	12.3			2800

Mission # 1 Run # 1 $S_{P[wo]}$ = 2 sec
August 7, 1947 Page # 2

Frame	t_{corr}	T_c	R_c	T_d	R_d	P_{sc}	P_{sd}	P_s	$[I]_{TLc}$	$[I]_{TLd}$	$[I]_{TL}$	Clock Time	V_a	Accel.	Altitude
—	sec.	mils	mils	mils	mils	mils	mils	mils	mils	mils	mils	sec	Knots	g's	Ft.
153	9.76	150	143	233	232	42	63	75.5	-7	-1	7.1	12.5	190	1.2	2800
157	10.02	152	144	233	233	43	62	75.4	-8	0	8.0	12.8			
161	10.28	154	145	232	231	44	64	77.6	-9	-1	9.1	13			2790
165	10.55	157	147	228	228	46	67	81.2	-10	0	10.0	13.2			2780
169	10.81	158	148	225	225	47	70	84.4	-10	0	10.0	13.5			
173	11.08	159	151	223	222	50	73	88.5	-8	-1	8.1	13.8			2770
177	11.34	160	152	223	221	51	74	90	-8	-2	8.2	14.0			
181	11.60	163	156	224	220	55	75	93	-7	-4	8.0	14.2			
185	11.86	161	158	224	220	57	75	94.2	-3	-4	5.0	14.5			
189	12.12	161	159	224	219	58	76	95.6	-2	-5	4.4	14.8			
193	12.39	169	161	223	217	60	78	98.5	-8	-6	10.0	15			
197	12.65	170	162	223	216	61	79	99.8	-8	-7	10.5	15.2			
201	12.92	170	163	222	215	62	80	101.2	-7	-7	9.8	15.4			
205	13.18	173	165	220	215	64	80	102.6	-8	-5	10.0	15.6			
209	13.45	176	169	219	210	68	85	108.8	-7	-9	11.4	15.8			
213	13.71	178	172	215	207	71	88	113.1	-6	-8	10.0	16.1			
217	13.98	180	174	210	203	73	92	11[illegible].4	-6	-7	9.2	16.4			
221	14.24	181	177	208	199	26	96	21.8	-4	-9	9.8	16.7			
225	14.50	182	177	207	197	76	98	123.3	-5	-10	11.2	17.0			
229	14.77	184	179	207	196	78	99	125.5	-5	-11	11.2	17.2	192		
233	15.03	186	182	209	195	81	100	128	-4	-14	14.5	17.5			
237	15.30	189	184	209	194	83	101	130.2	-5	-15	15.8	17.8			
241	15.56	191	187	207	192	86	103	133.2	-4	-15	15.5	18.0			
245	15.82	193	189	203	187	88	108	138.5	-4	-16	16.5	18.2	190		
249	16.09	194	192	199	182	91	113	144	-2	-17	17.1	18.5			
253	16.35	194	192	199	181	91	114	145	-2	-18	18.1	18.7			
257	16.61	194	193	200	181	92	114	145.5	-1	-19	19.0	18.9			
261	16.88	195	195	201	180	94	115	147.8	0	-21	21	19.1			
265	17.14	196	196	202	179	95	116	149.3	0	-23	23	19.3			2760
269	17.40	193	198	202	176	97	119	152.7	5	-26	26.4	19.5			
223	17.66	190	198	200	175	97	120	153.5	8	-25	2[illegible]	19.8			
277	17.93	188	201	201	175	100	120	155.5	13	-26	29.1	20.0			
281	18.19	197	205	204	173	104	122	160	6	-31	31.7	20.2			
285	18.46	193	211	205	172	110	123	164.4	18	-33	40.3	20.5			
289	18.71	177	214	203	172	113	123	166.3	37	-31	48.4	20.8		1.3	

Final time = 23.0 sec
" Frame = 298

Mission #1 — August 7, 1947

Run #2 — Page #1

$S_{P[WP]}$ = 2 sec.

Frame	t_{corr} (sec)	T_c (mils)	R_c (mils)	T_d (mils)	R_d (mils)	P_{se} (mils)	P_{sd} (mils)	P_a (mils)	$[I]_{TL_c}$ (mils)	$[I]_{TL_d}$ (mils)	$[I]_r$ (mils)	Clock Time (sec)	V_a (knots)	Accel. (g's)	Altitude (ft)
1	0	110	108	308	300	0	0	–	-2	-8	8.2	3.5	195	1.1	2480
5	.24	107	109	306	299	1	1	1.4	2	-7	7.3	3.7			
9	.48	109	107	304	296	-1	4	4.0	-2	-8	8.2	4.0			
13	.73	110	109	303	291	1	9	9.1	-1	-12	12.1	4.2			
17	.77	111	111	300	285	3	15	15.3	0	-15	15.0	4.5			
21	1.21	114	117	296	282	9	18	20.0	3	-14	14.3	4.8			
25	1.45	118	122	293	277	14	23	26.8	4	-16	16.5	5.0			
29	1.70	123	128	288	272	20	28	34.5	5	-16	16.7	5.2			
33	1.94	130	133	282	265	25	35	43.1	3	-17	17.3	5.5			
37	2.19	137	139	277	260	31	40	50.7	2	-17	17.2	5.8			
41	2.42	144	146	272	255	38	45	59.0	2	-17	17.2	5.8			
45	2.67	151	151	265	250	43	50	66.0	0	-15	15.0	6.1			
49	2.91	156	155	259	246	47	54	71.6	-1	-13	13.1	6.4			
53	3.15	160	157	253	241	49	59	76.7	-3	-12	12.3	6.7			
57	3.40	164	159	248	237	51	63	81.0	-5	-11	12.0	7.0			
61	3.64	165	158	245	234	50	66	82.8	-7	-11	13.0	7.3			
65	3.88	165	157	244	233	49	67	83	-8	-11	13.6	7.6			
69	4.12	164	154	242	232	46	68	82.2	-10	-10	14.1	7.9			
73	4.36	161	151	240	230	43	70	82.2	-10	-10	14.1	8.1			
77	4.61	157	147	237	227	39	73	82.7	-10	-10	14.1	8.2			
81	4.85	153	142	232	223	34	77	84.2	-11	-9	14.1	8.5			
85	5.09	151	140	226	219	32	81	87.2	-11	-7	13.0	8.8			
89	5.34	150	140	222	215	32	85	91.0	-10	-7	12.2	9.0		2500	2500
93	5.58	150	140	220	212	32	88	93.7	-10	-8	12.8	9.3			
97	5.82	148	141	222	212	33	88	94.1	-7	-10	12.2	9.5			
101	6.06	152	144	223	212	36	88	95.2	-8	-11	13.6	9.7		2520	2520
105	6.31	159	150	222	212	42	88	97.6	-9	-10	13.4	9.95			
109	6.55	163	155	219	211	47	89	100.7	-8	-8	11.3	10.2			
113	6.79	165	159	216	209	51	91	104.4	-6	-7	9.2	10.4			
117	7.04	168	163	212	206	55	94	109.0	-5	-6	7.1	10.6			
121	7.28	170	165	209	203	57	97	114.0	-5	-6	7.1	10.7			
125	7.52	173	169	209	202	61	98	115	-4	-7	8.0	10.9			
129	7.76	177	174	208	200	66	100	119	-3	-8	8.5	11.1			
133	8.00	181	178	210	201	70	99	120.8	-3	-9	9.5	11.4			
137	8.24	184	181	211	201	73	99	122.5	-3	-10	10.4	11.7		2500	2500
141	8.48	189	187	211	201	79	99	126	-2	-10	10.2	11.9			
145	8.73	193	190	210	199	82	101	129.4	-3	-11	11.4	12.1			
149	8.97	195	194	211	196	86	104	134.4	-1	-15	15.1	12.3			
153	9.21	199	199	210	195	91	105	138.4	0	-15	15.0	12.6			
157	9.46	205	205	212	192	97	108	144.2	0	-20	20.0	12.9			

Mission # 1 Run # 2 $S_{P[WP]}$ = 2 sec.
August 7, 1947 Page # 2

Frame	$t_{corr.}$	T_e	R_e	T_d	R_d	P_{se}	P_{sd}	P_s	$[I]_{TLe}$	$[I]_{TLd}$	$[I]_{TL}$	Clock Time	V_A	Accel.	Altitude
—	sec.	mils	mils	mils	mils	mils	mils	mils	mils	mils	mils	sec.	knots	g's	ft.
√161	9.94	211	212	210	190	104	110	150.8	1	-20	20.1	13.1	195	1.1	
165	10.18	216	219	211	185	111	115	158.6	3	-26	26.2	13.4			2480
169	10.42	223	226	206	182	118	118	166	3	-24	24.2	13.7			
173	10.67	224	231	205	177	123	123	173	7	-28	29.0	14.0			
177	10.91	226	233	202	179	125	121	178	7	-23	23.7	14.2			

Total Time = 16.4 sec.
" Frames = 213

4

Mission # 2
Aug. 7, 1947

Run # 6
Page # 1

$S_{P(wp)}$ = 2 sec.

Frame	$t_{corr.}$	T_e	R_e	T_d	R_d	P_{se}	P_{sd}	P_s	$[I]_{TLe}$	$[I]_{TLd}$	$[I]_{TL}$	Clock Time	V_{iq}	Accel.	Altitude
–	sec.	mils	mils	mils	mils	mils	mils	mils	mils	mils	mils	sec.	knots	g's	ft
1			102		295							5.8	178	1.2	3110
5			102		295							6.0			
9	0		102		295							6.2			
13	.26		102		295	0	3	3	3			6.4			
17	.52		104		289	2	6	6.4	2			6.7			
21	.78	112	109	285	287	5	8	9.4	~~4~~ 3	2	3.6	7.0			
25	1.04	116	114	284	285	12	10	15.6	~~5~~ 2	1	2.2	7.2			
29	1.3	118	118	280	280	16	15	21.9	0	0	0	7.5			
33	1.56	124	124	278	278	22	17	27.8	~~3~~ 0	0	0	7.8			
37	1.82	131	131	274	274	29	21	35.9	~~3~~ 0	0	0	8.1			
41	2.08	138	135	265	271	33	24	40.9	~~7~~ 3	-1	3.1	8.3			
45	2.34	142	139	270	267	37	28	46.5	~~8~~ 3	-2	3.6	8.5			
49	2.60	146	139	260	261	37	34	50	~~9~~ 7	-1	7.1	8.8			
53	2.86	147	139	255	256	37	39	53.8	~~11~~ 8	-1	8.1	9.0			
57	3.12	147	138	251	252	36	43	56.2	~~14~~ 9	-1	9.04	9.2			
61	3.38	146	135	247	247	33	48	58.4	~~15~~ 11	0	11	9.5			
65	3.64	145	131	245	245	29	50	58	~~15~~ 14	0	14	9.7			
69	3.90	143	128	242	243	26	52	58.3	~~14~~ 15	-1	15	10.0			
73	4.16	140	127	242	242	25	53	58.8	13	0	13	10.2			
77	4.42	137	123	242	243	21	52	56.3	~~13~~ 14	-1	14	10.4			
81	4.68	134	121	243	245	19	50	53.7	13	-2	13.1	10.7			
85	4.94	134	121	243	246	19	49	52.7	13	-3	13.3	11.0			
89	5.20	131	121	242	246	19	49	52.7	10	-4	10.8				
93	5.46	131	120	242	245	18	50	53.3	11	-3	11.5				
97	5.72	132	121	237	242	19	53	56.4	11	-5	12.1				
101	5.98	134	126	234	239	24	56	61	8	-5	9.4				
105	6.24	136	127	230	234	25	61	66.1	9	-4	9.8				
109	6.50	140	138	225	231	31	64	71.2	7	-6	9.2				
113	6.76	141	136	223	230	34	65	73.4	5	-7	8.6				
117	7.02	146	141	222	227	39	68	78.5	5	-5	7.1				
121	7.28	148	144	220	227	42	68	80	4	-7	8.1				
125	7.54	153	147	219	226	45	69	82.4	6	-7	9.2				
129	7.80	157	150	218	226	48	69	84.1	7	-8	10.7				
133	8.06	158	153	218	226	51	69	85.9	5	-8	9.4				
137	8.32	160	155	218	225	53	70	88	5	-7	8.6				
141	8.58	164	157	219	225	55	70	89	7	-6	9.2				
145	8.84	163	157	219	225	55	70	89	6	-6	8.5				

5

Mission # 2 Aug. 7, 1947

Run # 6 Page # 2

$S_{P[WP]}$ = 2 sec.

Frame	t_{corr}	T_e	R_e	T_d	R_d	P_{se}	P_{sd}	P_s	$[I]_{TL_e}$	$[I]_{TL_d}$	$[I]_{TL}$	Clock Time	V_A	Accel.	Altitude
–	sec.	mils	mils	mils	mils	mils	mils	mils	mils	mils	mils	sec.	knots	g's	Ft.
149	9.10	166	158	219	224	56	71	90.5	8.0	-5.0	9.4	9.4	178	1.2	3110
153	9.36	167	157	216	222	55	73	91.6	10.0	-6.0	11.6	—			
157	9.62	167	157	218	222	55	73	91.5	10	4	10.8				
161	9.88	167	157	222	222	55	73	91.5	10	0	10				
165	10.14	166	158	223	223	56	72	91.1	8	0	8				
169	10.40	167	160	224	223	58	72	92.5	7	1	7.07				
173	10.66	170	166	225	223	64	74	97.8	4	4	5.7				
177	10.92	176	173	222	217	71	78	105.6	3	5	5.8				
181	11.18														
185	11.44	187	187	217	206	85	89	122.6	0	11	11				
189	11.70	190	196	216	202	94	93	131.5	6	14	15.2				
193	11.96	195	203	217	198	101	97	139.5	8	19	20.5				

MISSION #3 RUN #3
AUGUST 7, 1947 PAGE #1

$Sp_{[WP]} = 2$ SEC.

	FRAME	t_{CORR}	T_c	R_e	T_d	R_d	P_{S_e}	P_{S_d}	P_S	$[I]_{TL_e}$	$[I]_{TL_d}$	$[I]_{TL}$	CLOCK TIME	V_A	ACCEL.	ALTITUDE
	—	SEC	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	SEC	KNOTS	g's	FEET
* FLAG IN	1			100		296							2.5	180	1.2	6900
	5			100		296							2.7			
	9			100		296							2.7			
	13			100		296							3.1			
	17			102		298							3.4			
	21			102		299.5							3.7			
FLAG OUT(24)	25	.00		99.5		299	0	0	0				4.0			
	29	.256		99		297	-1	-2	2.3				4.25			
	33	.512		98.5		293	-1.5	0	1.5				4.5			
	37	.767		100		287	0	4	4				4.75			
	41	1.02		103		282	3	10	10.5				4.95			
	45	1.28		106		276	6	15	16.2				5.2			
	49	1.53		109		273.5	9	21	22.8				5.45			
	53	1.79		112.5		272	12.5	24	27				5.7			
	57	2.04		114		271	14	26	29.5				5.95			
	61	2.30	119	116	268	268	16	29	33.2	-3	0	3	6.2			
	65	2.56	121	117	264	267	17	30	34.5	-4	+3	5	6.4			
	69	2.81	122	118	264	266	18	31	36	-4	+2	4.5	6.65			
	73	3.07	124	116	261	267	16	30	34	-8	6	10	6.9			
	77	3.32	124	116	262	267	16	30	34	-8	5	9.5	7.15			
	81	3.58	123	115	261	267	15	30	33.6	-7	6	9.2	7.4			
	85	3.84	121	113	261	266.5	13	30.5	33.5	-8	5	9.5	7.7			
	89	4.09	120	111	258	265	11	32	34	-9	7	11.2	7.95			
	93	4.35	119	108	255	264	8	33	34.5	-11	9	14	8.2			
	97	4.60	117	106.5	254	262.5	6.5	34.5	35	-10.5	8.5	13.5	8.45			
	101	4.86	116	106.5	251	260.5	6.5	36.5	37	-9.5	6.5	12.5	8.7			
	105	5.12	114.5	106	249	259	6	38	38.5	-9	10	13.5	8.95			
	109	5.36	112.5	105	246	257.5	5	39.5	40	-7	11.5	13.6	9.15			
	113	5.62	112.5	106	244	256	6	41	41.5	-6	12	13.6	9.4			
	117	5.88	113	106	240	255	6	42	42.6	-7	15	16.8	9.65			
	121	6.14	112	107	238	254	7	43	43.6	-6	16	17	9.85			
	125	6.40	113	109	236	252	9	45	46	-4	16	16.5	10.05			
	129	6.65	115	111	233	251	11	46	47.5	-4	18	18.5	10.25			
	133	6.90	116	113	231	249	13	48	50	-3	18	18.4	10.5	185		
	137	7.15	117	114	228	247	14	50	52	-03	19	19.3	10.75			
	141	7.41	118	115	225.5	245	15	52	54.5	-3	20	20.3	11.0			
	145	7.66	117	116	224	244	16	53	55.8	-1	20	20	11.25			
	149	7.94	118	116	223	243	16	54	56.8	-2	20	20.2	11.45			6860
	153	8.20	118	115	223	245	15	52	54.5	-3	22	22.2	11.75			

MISSION #3 RUN #3
AUGUST 7, 1947 PAGE #2

$S_{P[WP]} = 2$ SEC

FRAME	t_{corr}	T_e	R_e	T_d	R_d	P_{s_e}	P_{s_d}	P_s	$[I]TL_e$	$[I]TL_d$	$[I]TL$	CLOCK TIME	V_A	ACCEL.	ALTITUDE
—	SEC	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	SEC	KNOTS	g's	FEET
157	8.46	117.5	115	224	245.5	15	51.5	54	-2.5	21.5	21.7	11.95	185	1.2	6860
161	8.71	118	115	226	248.5	15	48.5	51	-3	22.5	22.7	12.2			
165	8.96	120	116	229	253	16	44	47	-4	24	24.2	12.45			
169	9.23	123	117	234	257.5	17	39.5	43	-6	23.5	24.5	12.65			
173	9.48	125	118	240	263	18	34	38.5	-7	23	24	12.85			
177	9.74	125	119	246	267	19	30	35	-6	21	21.8	13.05			
181	10.00	125	118.5	251.5	271	18.5	26	31.5	-6.5	19.5	20.5	13.3			
185	10.25	125	118	256	274	18	23	29	-7	18	19.2	13.5			
189	10.50	126	119	259	274	19	23	30	-7	15	16.5	13.8			
193	10.75	127	119.5	260	272	19.5	25	32	-6.5	12	13.4	14.0			
197	11.02	129	122	259.5	268.5	22	28.5	36	-7	9	11.4	14.25			
201	11.28	131.5	124	259	266	24	31	39.5	-7.5	7	10.4	14.5			
205	11.52	132.5	125.5	257.5	262	25.5	35	43.5	-7	4.5	7.8	14.75			
209	11.80	135	128	257	259.5	28	37.5	47	-7	2.5	7.4	15			
213	12.05	136	131	256	257	31	40	51	-5	1	5.1	15.25			
217	12.30	137.5	131.5	254	254.5	31.5	42.5	53	-6	+0.5	6	15.45			
221	12.56	139	133	254	251.5	33	45.5	56.5	-6	-2.5	6.3	15.7			
225	12.82	140.5	136	253	250.5	36	46.5	59	-3.5	-2.5	4.2	15.95			
229	13.08	142.5	138	252	248	38	49	62	-3.5	-4	5.2	16.2			
233	13.32	146	142	251	247	42	50	65.5	-3	-4	5	16.4			
237	13.59	148.5	145.5	251	244.5	45.5	52.5	69.5	-3	-5.5	6.2	16.65			
241	13.85	153	149.5	250	242.5	49.5	54.5	74	-3.5	-7.5	8.5	16.9			
245	14.10	156	155	250.5	240	55	57	79.4	-4	-9.5	10.5	17.2			
249	14.35	158.5	158.5	251.5	239	58.5	58	82.5	0	-10.5	10.5	17.45			
253	14.61	161	163	250	237	63	60	87	+2	-13	13.1	17.7			
257	14.88	164.5	167	249	234	67	63	92	2.5	-15	15.5	17.95			
261	15.12	169	171.5	246	230	71.5	67	98	2.5	-16	16.5	18.2			
265	15.38	173	176	243	226.5	76	70.5	104	3	-16.5	16.9	18.45			
269	15.62	176	179.5	239	222	79.5	75	109	3.5	-17	17.5	18.7			
273	15.90	178	183	236	219	83	78	114	5	-17	17.6	18.95			
277	16.15	179	186	233	214	86	83	119.5	7	-19	20	19.2			
281	16.40	180	190	232	210.5	90	86.5	124	10	-21.5	24	19.45			
285	16.65	184	196	230	206.5	96	90.5	131	12	-23.5	26.4	19.7			
289	16.92	188.5	204.5	229	204	104.5	93	139	16	-25	29.8	19.9			
293	17.18	193.5	212	227	201.5	112	95.5	147	18.5	-25.5	31.5	20.1			
297	17.42	199	222	228	200	122	97	155	23	-28	36.5	20.35			

RETICLE CAMERA → 352 355 ← CAMERA REAR INSTRUMENT

25.0

MISSION # 3
AUGUST 7, 1947

Run # 4
Page #1

$Sp_{[wp]}$ = 1 sec.

	Frame	T_{corr}	Te	Re	Td	Rd	Pse	Psd	Ps	$[I]TL_e$	$[I]TL_d$	[I] TL	Clock Time	VA	Accel.	Altitude
	–	Sec	mils	mils	mils	mils	mils	mils	mils	mils	mils	mils	sec.	Knots	g's	Feet
[illegible] →	1			99		294							2.4	196	1.1	7160
	5			99		295							2.7			
	9			99		295							2.9			
	13	0.00		99		295			0				3.1			
Flap out →	17	0.259		101		294	2	1	2.2				3.4			
	21	.518		104		289	5	6	7.8				3.7			
	25	.776		105.5		286	6.5	9	11.0				4.0			
	29	1.04		106		284	7	11	13.0				4.2			
	33	1.30		110		285	11	10	14.8				4.4			
	37	1.55		110		284	11	11	15.6				4.7			
	41	1.81		112		282	13	13	18.5				5.0			
	45	2.07		113		278	14	17	22.0				5.2			
	49	2.33		114		273	15	22	26.7				5.4			
	53	2.59		115		267	16	28	32.5				5.6			
	57	2.85		115		262	16	33	36.7				5.8			
	61	3.11		114		258	15	37	40.0				6.0			
	65	3.37		113		253	14	42	44.5				6.2			
	69	3.63		112		251	13	44	46.2				6.5			
6	73	3.89		112		248	13	47	49.0				6.8			
	77	4.14		114		247	15	48	50.5				7.0			
	81	4.40		116		247	17	48	51.0				7.2			
	85	4.66	122	119	249	248	20	47	51.3	-3	-1	3.2	7.5			
	89	4.92	125.5	121.5	250	250	22.5	45	50.5	-4	0	4	7.8			
	93	5.17	128	124	249	250.5	25	44.5	51.3	-4	1.5	4.9	8.0			
	97	5.44	132	127	249	251	28	44	52.4	-5	2	5.3	8.2			
	101	5.69	135	129	249	252	30	43	52.5	-6	7	9.2	8.5			
	105	5.96	139	131	247	250.5	32	44.5	55.0	-8	3.5	8.8	8.8			
	109	6.21	141	133	246	250	34	45	56.6	-8	4	9.0	9.0			
	113	6.47	142	133	243	247	34	48	59.0	-9	4	9.8	9.3			
	117	6.73	143	132	238	245	33	50	60.2	-11	7	13.0	9.6			
	121	6.98	143	130	234	242	31	53	61.5	-13	8	15.3	9.9			
	125	7.24	140	127	231	238	28	57	63.7	-13	7	14.8	10.1			
	129	7.51	136	123	226	236	24	59	64.0	-13	10	16.5	10.4			7110
	133	7.76	133	119	220	232	20	63	66.4	-14	12	18.5	10.7			
	137	8.02	132	119	219	230	20	65	68.3	-13	11	16.6	11.0			
	141	8.28	133	120	215	229	21	66	69.4	-13	14	18.6	11.2			
	145	8.54	132	121	215	229	22	66	69.7	-11	14	18.4	11.4			
	149	8.80	133	123	214	229	24	66	70.9	-10	15	18.0	11.6			

MISSION #3 AUGUST 7, 1947

RUN #4 PAGE #2

$S_P[WP] = 2$ sec

FRAME	t_{corr}	T_e	R_e	T_d	R_d	P_{S_e}	P_{S_d}	P_S	$[I]TL_e$	$[I]TL_d$	$[I]TL$	CLOCK TIME	V_A	ACCEL.	ALTITUDE
–	SEC	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	SEC	KNOTS	g's	FEET
153	9.06	134	124.5	213	228.5	25.5	66.5	71.5	-9.5	15.5	18.3	11.8	196	1.1	7110
157	9.32	135	126	213	228.5	27	66.5	72.0	-9	15.5	18.0	12.0			
161	9.57	137	131	215	230	32	65	72.6	-6	15	16.2	12.2			
165	9.83	140	132	217	232	33	63	71.2	-8	15	17.0	12.4			
169	10.10	141	134	222	236	35	59	68.7	-7	14	15.5	12.6			
173	10.35	143	136	227	239	37	56	67.2	-7	12	14.0	12.9			
177	10.62	145.5	137.5	231	242.5	38.5	52.5	65.3	-8	11.5	14.0	13.1			
181	10.88	149	140	234	243.5	41	51.5	66.4	-9	9.5	13.2	13.4			
185	11.13	150.6	142	237.5	244	43	51	66.8	-8.5	6.5	10.6	13.6			
189	11.40	152	143	240	244	44	51	67.5	-9	4	9.8	13.8			
193	11.65	153	144	242	243	45	52	68.8	-9	+1	9.2	14.0			7100
197	11.91	155	147	241	240	48	55	73.0	-8	-1	8.2	14.2			
201	12.17	157	149	241	237	50	58	76.7	-8	-4	8.8	14.5			
205	12.43	159	150.5	240	234	51.5	61	80.3	-8.5	-6	10.0	14.8			
209	12.69	160	153	239	231	54	64	83.8	-7	-8	10.7	15.0			
213	12.95	161	155	240	229	56	66	86.7	-6	-11	12.5	15.2			
217	13.21	161	157	240	228.5	58	66.5	89.5	-4	-11.5	12.2	15.5			
221	13.47	163	159.5	239	226	60.5	69	91.5	-3.5	-13	13.4	15.8			
225	13.73	165	164	240	225	65	70	95.5	-1	-15	15.1	16.0	194		
229	13.98	168	169	241	224	70	71	99.8	+1	-17	17.0	16.2			
233	14.24	171	175	243	223	76	72	104.6	4	-20	20.4	16.4			
237	14.50	174	183	244	221	84	74	112.0	9	-23	24.6	16.7			
241	14.76	176	189	244	220	90	75	117.2	13	-24	27.4	17.0			
245	15.02	179	195	242	218	96	77	122.5	16	-24	28.8	17.2	192		
249	15.28	182	200	241	213	101	82	129.6	18	-28	33.3	17.5			
253	15.54	185	207	237	209	108	86	137.5	22	-28	35.6	17.8			
257	15.80	188	215	234	204	116	91	147.0	27	-30	40.4	18.0	190		
261	16.08	192	224	229	200	125	95	156.5	32	-29	43.3	18.2			
265	16.34	197	234	224	195	135	100	167.3	37	-29	47.0	18.5			
RETICLE CAMERA → 295	317 ← REAR INSTRUMENT CAMERA											21.5			

10

Mission #1 Run # 3 $S_{P(wos)}$ = 4 sec.
August 7, 1947 Page #1

Frame	$t_{corr.}$	Te	Re	Td	Rd	P_{se}	B_d	P_s	$[I]_{TL\,e}$	$[I]_{TL\,d}$	$[I]_{TL}$	Clock Time	Va	Accel.	Altitude
–	sec.	mils	mils	mils	mils	mils	mils	mils	mils	mils	mils	sec	knots	g's	Feet
1	–	87	87	296	296	0	0	0	0	0	0	1.[illegible]	190	1.1	2500
5	–	88	88	295	295	0	0	0	0	0	0	1.5			
9	–	88	88	295	295	0	0	0	0	0	0	1.8			
13	0	88	88	295	295	0	0	0	0	0	0	2.1			
17	.26	91	91	284	284	3	11	11.4	0	0	0	2.35			
21	.52	93	93	279	279	5	16	16.7	0	0	0	2.7			
25	.78	95	95	273	273	7	22	23	0	0	0	3.2			
29	1.04	97	98	271	270	10	25	27	1	-1	1.41	3.5			
33	1.30	100	102	272	266	14	29	32.2	2	-6	6.3	3.7			
37	1.56	103	108	271	264	20	31	37	5	-7	8.6	3.5			
41	1.82	110	116	270	261	28	34	44.2	6	-9	10.8	3.8			
45	2.08	117	125	268	256	37	39	53.8	8	-12	14.4	4.05			
49	2.34	125	135	265	250	47	45	65	10	-15	18	4.3			
53	2.60	133	144	258	243	56	52	76.5	11	-15	18.6	4.55			
57	2.86	148	154	249	253	66	62	90.7	12	-16	20	4.8			
61	3.12	162	163	239	233	75	63	97.3	11	-6	12.5	5.05			
65	3.38	162	172	230	213	84	82	117.5	10	-17	19.7	5.30	188	1.2	2370
69	3.64	167	178	222	206	90	89	126	11	-12	16.2	–			
73	3.90	174	180	217	201	92	94	131	6	-16	17.1	5.55			
77	4.16	180	184	213	200	96	95	134.5	4	-13	13.6	5.8			
81	4.42	184	184	211	197	96	98	136.5	0	-14	14	6.05			
85	4.68	183	181	209	195	93	100	136	-2	-14	14.1	6.25			
89	4.94	180	177	205	192	89	103	135.5	-3	-13	13.4	6.5			
93	5.20	176	170	199	186	82	109	135.8	-6	-13	14.3	6.75			
97	5.46	172	163	192	181	75	114	136	-9	-11	14.2	7.00			
101	5.72	169	158	185	174	70	121	139	-11	-11	15.5	7.25			
105	5.98	166	154	180	170	66	[illegible]	141	-12	-10	15.6	7.5			
109	.24	164	151	176	168	63	127	141.5	-13	-8	15.2	7.75			
113	6.50	161	149	173	165	51	130	143.4	-13	-8	14.4	8.00			
117	6.76	157	144	170	163	56	132	143	-13	-7	14.8	8.2			
121	7.02	153	141	168	160	53	135	145	-12	-8	14.8	8.45			
125	7.28	141	130	167	160	42	135	143	-11	-7	12.6	8.7			
129	7.54	149	136	168	161	48	134	140.5	-13	-7	14.8	8.95	191		
133	7.80	150	137	167	161	49	134	143.5	-13	-6	14.3	9.2			
137	8.06	151	139	166	162	51	133	142	-12	-4	12.6	9.45		1.1	
141	8.32	151	139	163	162	51	133	142	-12	-1	12.0	9.7			
145	8.58	151	140	161	160	52	135	145	-11	-1	11.0	9.95	189		
149	8.84	150	141	160	160	53	135	145	-9	0	9	10.2			

MISSION #1 RUN #3
AUGUST 7, 1947 PAGE #2

$S_{P[wp]}$ = 4 sec

FRAME	$t_{corr.}$	Te	Re	Td	Rd	Psc	Psd	Ps	$[I]TL_c$	$[I]TL_d$	[E]TL	Clock Time	VA	Accel.	Altitude
–	sec.	mils	mils	mils	mils	mils	mils	mils	mils	mils	mils	Sec.	Knots	g's	FEET
153	9.10	150	141	160	160	53	135	145	-9	0	9				
157	9.36	154	148	160	160	60	135	148	-6	0	6	10.45			
161	9.62	159	153	161	159	65	136	150.5	-5	-2	5.4	10.7	189	1.1	2370
165	9.88	160	160	159	156	72	139	156	0	-3	3	10.95			
169	10.14	166	164	155	154	76	141	160	-2	-1	2.24	11.20			
173	10.40	174	173	152	151	85	144	166.8	-1	-1	1.4	11.45			
177	10.66	184	181	149	149.5	93	145	172	-3	0.5	3	12			
181	10.92	192	191	148	148	103	147	179	-1	0	1	12.3			
185	11.18	199	199	148	148	111	147	183	0	0	0	12.75			
189	11.44	204	204	147	148	116	147	186.5	0	1	1	13.1			

12

MISSION # 1 RUN #4 $S_{P(WP)}$ = 4 SEC.
AUGUST 7, 1947 PAGE 1

FRAME	t corr.	Te	Re	Td	Rd	Pse	Psd	Ps	(I)TLe	(I)TLd	(I)TL	Clock Time	VA	Accel.	ALT.
—	SEC	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	SEC.	KNOTS	G's	FEET
1	UNCAGED	92	86	292	296	-1	1	0	-6	4	10	1.9	188	1.1	2400
5	0	91	87	294.5	297.5	0	-.5	0	-4	3	5	2.1			
9	.258	90	86	297	299	-1	-2.0	2.24	-4	2	4.5	2.3			
13	.516	89	88	297.5	295	1	2	2.24	-5	-2.5	5.5	2.6			
17	.774	91.5	90	293	290	3	7	7.6	-1.5	-3	3.3	2.8			
21	1.032	94	94	287	282.5	7	13.5	15.3	0	-3.5	3.5	3.0			
25	1.29	96	98	284	278	11	18	21	2	-6	6.3	3.25			
29	1.548	98.5	102	279	275	15	22	26.5	3.5	-4	5.3	3.6			
33	1.806	101	106.5	277	272	19.5	25	31.8	5.5	-5	7.4	3.85			
37	2.062	106.5	112	272	267	25	30	39.3	5.5	-5	7.2	4.05			
41	2.32	111	117	268	262	30	35	46.3	6.0	-4	7.8	4.2			2390
45	2.58	117	123	262	257	36	40	54	6.0	-5	7.8	4.55			
49	2.84	124	130	257	252	43	45	62.4	6.0	-5	7.2	4.75			2350
53	3.10	130	136	252	248	49	49	69.3	6.0	-4	7.8	5.0			
57	3.35	136	141	247	241	54	56	78	5.0	-6	8.6	5.2			
61	3.61	141	146	242	235	59	62	85.5	5.0	-7	8.1	5.45			2330
65	3.87	147	151	238	231	64	66	92	4.0	-7	5.1	5.75			
69	4.13	152	153	233	228	66	69	95.6	1.0	-5	5.5	5.93			2320
73	4.38	155	155	228.5	223	68	74	100.5	0	-5.5	5	6.15			2315
77	4.64	155	155	224	219	68	78	103.5	0	-5	4.5	6.42			
81	4.90	155	153	218	214	66	83	106.3	-2	-4	6.7	6.72			
85	5.16	154	148	213	210	61	87	106.3	-6	-3	7.6	6.95			
89	5.42	152	145	208	205	58	92	109	-7	-3	9.5	7.2			2300
93	5.68	161	142	204	201	55	96	110.8	-9	-3	10.9	7.45			
97	5.94	149.5	139	201	198	52	99	112	-10.5	-3	12.4	7.7			
101	6.19	147	135	199	196	48	101	112	-12	-3	14.1	8			
105	6.45	146	132	198	196	45	101	111.8	-14	-2	13.2	8.2			
109	6.70	144	131	197.5	197	44	100	109.5	-13	-2.5	14.	8.4			
113	6.96	142	128	195	195	41	102	110	-14	0	13	8.7			
117	7.21	138	125	190	191	38	106	113	-13	1	16.1	8.95			
121	7.48	136	120	186	187	33	110	115	-16	2	14.3	9.15			
125	7.74	133	119	178	182	32	115	119.5	-14	3	16.1	9.4			
129	8.0	130	115	174	180	28	117	120	-15	6	16.1	9.65			
133	8.26	126	112	172	178	25	119	121.5	-13	6	14.6	9.9			
137	8.52	122.5	109	172	178.5	22	118.5	120	-12.5	6.5	14.6	10.1			
141	8.78	121	107	173	181	20	116	117.5	-14	8	16.1	10.3			
145	9.04	119	106	177	186	19	111	113	-13	9	15.8	10.55			
149	9.29	118	105	180	191.5	18	105.5	107.3	-13	11.5	17.3	10.8			

MISSION #1 AUGUST 7, 1947 RUN #4 PAGE 2 $S_{P(WP)}$ = 4 sec.

FRAME	t corr	T_e	R_e	T_d	R_d	P_{se}	P_{sd}	P_s	(I)T_{Le}	(I)T_{Ld}	(I)T_L	Clock Time	V_A	Accel.	ALT.
—	Sec	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	Sec	KNOTS	G's	FEET
153	9.55	116	104	183	196	17	101	102.8	-12	13	17.6	11.05	188	1.1	2300
157	9.8	112	102	184	197	15	100	101.4	-10	13	16.4	11.25			
161	10.06	111	103	182	195	16	102	103.7	-8	13	15.2	11.5			
165	10.32	111	103	186	194	16	103	104.5	-8	8	11.3	11.85			
169	10.58	112	105	180	192	18	105	106.8	-7	12	13.9	12.05			
173	10.82	112	106	179.5	192	19	105	107	-6	12.5	13.8	12.25			
177	11.1	112	110	179	191.5	23	105.5	107.9	-2	12.5	12.6	12.55			
181	11.35	116	114	180	191.5	27	105.5	108.7	-2	11.5	11.6	12.75			
185	11.6	121	119	180	191.5	32	105.5	110.2	-2	11.5	11.6	12.95			
189	11.85	126	124	181	192.5	37	103.5	110.2	-2	12.5	12.6	13.02			
193	12.12	129.5	129	183	196	42	101	109.5	-0.5	13	13	13.45			
197	12.38	133	132	186	197.5	45	99.5	110	-1.0	11.5	11.5	13.7			
201	12.63	136	136	189	200	49	97	108.8	0	11	11	13.95			
205	12.89	141	139	190	201	52	96	109.3	-2	11	11.1	14.2			
209	13.16	145	143	189	200	56	97	112	-2	11	11.1	14.45			
213	13.40	147	145	186.5	198	58	99	115	-2	11.5	11.7	14.75			
217	13.66	147	146	182.5	193	59	104	119.8	-1	10.5	10.6	14.95			
221	13.92	147	146	178.5	188	59	109	123.5	-1	9.5	9.6	15.2			
225	14.17	147	146	173	181	59	116	130	-1	8	8.1	15.4			
229	14.43	146	146	168	175	59	122	135	0	7	7	15.6			
233	14.70	145	145	168.5	170	58	127	139.5	0	5	5	15.85			
237	14.95	145.5	145	164	168	58	129	141	-0.5	4	4	16.2			
241	15.21	147.5	145	166	169	58	128	140.5	-2.5	3	4.9	16.4			
245	15.47	147	143	171	173	56	124	135.5	-4	2	4.4	16.6		1.2	
249	15.72	144	139	178	180	52	117	128	-5	2	5.4	16.85			
253	16.0	143	136	185	186	49	111	120.5	-7	1	7.1	17.05			
257	16.25	142	134	190	191	47	106	116	-8	1	8.1	17.25			
261	16.51	142	134	193	192	47	105	115	-8	-1	8.1	17.7			
265	16.77	143	133	193	192	46	105	114.5	-10	-1	10.1	18			
269	17.02	142	134	194	190.5	47	106.5	116	-8	-2.5	8.5	18.15			
273	17.29	142	133	195	190	46	107	116	-9	-5	10.3	18.35			
277	17.54	142	134	194	188	47	109	118	-8	-6	10	18.7			
281	17.80	143	136	193	186	49	111	121	-7	-7	9.96	18.95			
285	18.05	145	139	193	184	52	113	124	-6	-9	10.8	19.1			
289	18.31	149	143	192	181	56	116	128	-6	-11	12.5	19.3			
293	18.57	153	149.5	190	178	62.5	119	133.6	-3.5	-12	12.5	19.5			
297	18.83	155.5	154	187	174	67	123	139.5	-1.5	-13	13.1	19.8			
301	19.08	159	158	183.5	170.5	71	127.5	145.5	-1	-13	13.1	20.1			

MISSION #1 AUGUST 7, 1947

RUN #4 PAGE 3

$S_{P(WP)}$ = 4 SEC.

FRAME	t_{corr}	T_e	R_e	T_d	R_d	P_{se}	P_{sd}	P_s	(I)TL_e	(I)TL_d	(I)TL	CLOCK TIME	V_A	Accel.	ALT.
—	SEC	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	SEC	KNOTS	G's	FEET
305	19.33	162	162	181	167	75	130	149.5	0	-14	14	20.35	188	1.2	2300
309	19.59	164	167.5	181	164	80.5	133	155	3.5	-17	17.3	20.5			
313	19.87	168	173	178	160	86	137	161	5	-18	18.6	20.75			
317	20.13	173	180	175	155.5	93	141.5	169	7	-19.5	20.7	21.0			
321	20.38	178	187	171	149.5	100	147.5	177.5	9	-21.5	23.2	21.25			
325	20.64	182	196	168	145	109	152	186.5	14	-23	27	21.5			
422	FINAL FRAME SIGHT CAMERA									FINAL TIME		29.2			

MISSION # 2 RUN # 5
7 AUGUST, 1947 PAGE 1

$S_{P(WD)}$ = 4 SEC.

FRAME	t_{com}	T_e	R_e	T_d	R_d	P_{se}	P_{sd}	P_s	(I)TLe	(I)TLd	(I)TL	CLOCK TIME	V_A	ACC.	ALT.
—	SEC.	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	SEC.	KNOTS	G'S	FEET
1			102		296							4.8	175	1.1	2820
5			102		296							5.1			
9	UNCAGE 0		102		296							5.4			
13	.26		101		294	−1	2	2.24				5.6			
17	.52		101		292	−1	4	4.08				5.9			
21	.78		103		289	1	7	7.07				6.2			
25	1.04		107		286	5	10	11.2				6.9			
29	1.30		111		283.5	9	12.5	15.3				6.7			
33	1.56		117		279	15	17	22.8				6.9			
37	1.82	117	125	284	273.5	23	22.5	32.2	−8	10.5	13.1	7.1			
41	2.08	122	130	278	266	28	30	41	−8	12	14.9	7.4			
45	2.34	126	137	273	260	35	36	50.3	−11	13	17	7.7			
49	2.60	131	142	267	252	40	44	59.6	−11	15	18.6	8			
53	2.86	136	147	286	245	45	51	68.1	−11	17	20.2	8.2			
57	3.12	141	153	259	240	51	56	74.8	−12	19	22.8	8.5			2840
61	3.38	150	160	258	237	58	59	82.8	−10	18	20.3	8.8			
65	3.69	155	165	253	232.5	63	63.5	89.6	−10	20.5	22.9	9			
69	3.90	161	170	249	228	68	69	96.3	−9	21	23	9.2			
73	4.16	161	176	245	229	74	72	103.3	−15	23	22.5	9.4			
77	4.42	171	180	240	218	78	78	110.4	−9	22	23.8	9.7			
81	4.68	175	181	234	212	79	84	115.3	−6	22	22.8	9.9			
85	4.94	177	182	225	205	80	91	121	−5	20	20.8	10.1			
89	5.20	177	181	218	196	79	100	127	−4	22	22.9	10.9			
93	5.46	176	178	212	192	76	109	128.4	−2	20	20.1	10.7			
97	5.72	175	176	209	190	74	106	129	−1	19	19	11			2820
101	5.98	174	174	207	187	72	109	130	0	20	20	11.2			
105	6.24	173	172	205	185	70	111	130.7	1	20	20	11.5			
109	6.50	173	171	202	183	69	113	132	2	19	19.1	11.7			
113	6.76	174	172	198	178	70	118	136.8	2	20	20.1	11.9			
117	7.02	176	173	189	172	71	129	142.5	3	17	17.2	12.1			
121	7.28	178	174	180	165	72	131	149	6	15	16	12.3			
125	7.54	177	173	172	160	71	136	153	4	12	12.6	12.5			
129	7.80	175	172	167	155	70	141	157.2	3	12	12.4	12.7			
133	8.06	176	173	163	153	71	143	159.1	3	10	10.4	13			
137	8.34	177	173	162	153	71	143	159.1	4	9	9.8	13.2			
141	8.58	177	174	162	154	72	142	159	3	8	8.5	13.5			
145	8.84	177	175	164	156	73	140	157.6	2	8	8.3	13.7			
149	9.10	179	176	165	159	74	137	155	3	6	6.8	14			

MISSION #2 RUN #5 $S_{p(WP)}$ = 4 SEC.

7 AUGUST, 1947 PAGE 2

FRAME	t_{corr}	T_e	R_e	T_d	R_d	P_{se}	P_{sd}	P_s	(I)TL_e	(I)TL_d	CLOCK TIME	(I)TL	V_A	Acc.	ALT.
—	SEC.	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	SEC.	MILS	KNOTS	G'S	FEET
153	9.36	181	177	165	160	75	136	155	4	5	19.2	5.6	175	1.1	2820
157	9.62	182	178	164	158.5	76	137.5	156.5	4	5.5	19.4	6.7			
161	9.88	184	179	160	156	77	140	159.5	5	4	14.6	6.4			2820
165	10.14	187	182	155	153	80	143	163	5	2	19.9	5.9			
169	10.40	190	185	150	149	83	147	168.5	5	1	15.1	5.1			
173	10.66	193	188	144.5	145	86	151	173	6	-.5	15.3	5			
177	10.92	195	189	142	144	87	152	174.5	6	-2	15.6	6.3			
181	11.18	196	192	140	142	90	154	178	4	-2	15.8	4.45			
185	11.44	198	193	139	142	91	154	178.5	5	-3	16.1	5.8			
189	11.70	198	193	139	142	91	154	179	5	-3	16.3	5.8			
193	11.96	200	195	139	142	93	154	179	5	-3	16.5	5.8			
197	12.22	202	198	141	145	96	151	181.5	4	-4	16.8	5.65			
201	12.48	204	202	141	144	100	152	184.5	2	-3	17.0	3.6			
205	12.74	206	204	139	140	102	156	185.5	2	-1	17.3	2.25			
209	13.00	210	208	135	140	106	156	188	2	-5	17.5	5.4			
307	FINAL	SIGHT	CAMERA	FRAME							24.8				
327	"	INST.	"	"											

MISSION #3 Run #2 Sp(wp) 4 secs
Aug 7 '47 Page #1

Frame	t_{corr}	T_e	R_e	T_d	R_d	P_{se}	P_{sd}	P_s	$[I]_{TLe}$	$[I]_{TLd}$	$[I]_{TL}$	Clock Time	VA	Accel.	Altitude
–	Secs	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Secs	Knots	g's	Feet
1			103		301							6.6	175	1.2	6380
5			103		301							6.8	"	"	"
9			101		300							7.1	"	"	"
13			99		299							7.4	"	"	"
17			99		299							7.7	"	"	"
21			99		298							8.0	"	"	"
25	.000		101		297	0	0	0				8.2	"	"	"
UNCAGED 29	.259		101		296	1	3	3.1				8.4	"	"	"
33	.518		106		292	6	7	8.5				8.6	"	"	"
37	.777		111		289	11	10	15.0				8.9	"	"	"
41	1.036		117		284	17	15	22.7				9.2	"	"	"
45	1.295		123		279	23	20	30.5				9.4	"	"	"
49	1.554	127	127	276	276	27	23	35.4	0	0	0	9.6	"	"	"
53	1.813	132	132	274	271	32	28	42.5	0	3	3	9.9	"	"	"
57	2.072	137	137	266	270	37	29	47.1	0	4	4	10.0	"	"	"
61	2.331	141	141	261	264	41	35	54.0	0	3	3	10.2	"	"	"
65	2.590	145	145	260	255	45	44	62.8	0	5	5	10.4	"	"	"
69	2.840	150	147	255	251	47	48	67.2	-3	4	5.	10.6	"	"	"
73	3.108	153	149	250	245	49	54	73.0	-4	5	6.2	10.8	"	"	"
77	3.367	156	151	245	241	51	58	77.5	-5	4	6.2	11.0	"	"	"
81	3.626	157	152	241	237	52	62	80.8	-5	4	6.2	11.3	"	"	"
85	3.885	157	150	234	233	50	66	83.0	7	1	7.0	11.5	"	"	"
89	4.144	157	147	230	229	47	76	84.5	10	1	10.0	11.8	"	"	"
93	4.403	157	146	227	226	46	73	86.3	11	1	11.0	12.0	"	"	"
97	4.662	156	144	223	223	44	76	88.0	12	0	12.0	12.3	"	"	"
101	4.921	156	142	219	220	42	79	89.5	14	1	14.0	12.5	"	"	"
105	5.180	153	139	217	217	39	82	91.0	14	0	14.0	12.8	"	"	"
109	5.439	150	137	214	215	37	84	92.0	13	1	13.0	13.0	"	"	"
113	5.698	150	135	211	213	35	86	93.0	15	2	15.0	13.3	"	"	"
117	5.959	147	133	208	210	33	89	95.0	14	2	14.0	13.5	"	"	"
121	6.216	147	132	205	210	37	89	96.5	10	5	11.0	13.7	"	"	"
125	6.475	147	134	204	207	34	92	98.5	13	3	13.2	13.9	"	"	"
129	6.734	147	135	200	205	35	94	100.5	12	5	13.0	14.2	"	"	"
133	6.993	146	134	196	203	34	96	102.0	12	7	14.1	14.6	"	"	"
137	7.250	145	135	192	200	35	99	105.4	10	8	13.0	14.9	"	"	"
141	7.511	147	137	[illegible]	197	37	102	109.0	10	9	14.6	15.1	"	"	"
145	7.770	150	141	[illegible]	194	41	105	112.8	9	9	13.8	15.3	"	"	"
149	8.029	153	145	181	192	45	107	116.3	8	11	14.0	15.5	"	"	"
153	8.255	157	151	177	190	50	109	120.5	6	13	14.5	15.8	"	"	"

Mission #3 Aug 7, '47 Run #2 Page #2 $S_{p(wp)}$ - 4 secs

157	8.547	160	156	174	188	56	111	124.5	- 4	+ 14	14.5	16.1	17.5	1.2	6380
161	8.806	164	161	171	185	61	114	130.0	3	14	14.4	16.3	"	"	"
165	9.065	168	165	168	183	65	116	133.0	3	15	15.5	16.5	"	"	"
169	9.324	175	171	166	181	70	118	138.0	4	15	15.7	16.7	"	"	"
173	9.583	183	180	165	180	80	119	144.0	3	15	15.5	16.9	"	"	"
177	9.842	190	185	163	179	85	120	147.0	5	16	16.8	17.1	"	"	"
181	10.10	195	190	163	179	90	120	149.0	5	16	16.8	17.3	"	"	"
185	10.36	200	194	163	178	94	121	152.5	6	15	16.9	17.7	"	"	"
189	10.62	204	195	164	179	95	120	152.0	9	15	17.5	18.0	"	"	"
193	10.88	205	195	165	180	95	119	151.5	10	15	18.0	18.3	"	"	"
197	11.14	207	193	166	181	93	118	150.0	14	15	20.5	18.5	"	"	"
201	11.39	209	192	166	181	92	118	149.0	17	15	22.1	18.8	"	"	"
205	11.66	210	192	167	182	92	117	148.5	18	15	23.5	19.0	"	"	"
209	11.91	210	190	167	181	90	118	148.0	20	15	25.0	19.2	"	"	"
213	12.17	209	189	168	179	89	120	148.5	20	11	23.0	19.5	"	"	"
217	12.43	206	189	173	178	89	121	149.5	17	5	17.8	19.7	"	"	"
221	12.69	206	189	167	174	89	125	153.0	17	7	19.5	20.0	"	"	"
225	12.95	210	195	166	172	95	127	158.0	15	6	16.0	20.2	"	"	"
229	13.21	214	203	166	188	103	131	166.5	- 11	2	11.3	20.4	"	"	"
233	13.47	219	214	166	165	114	134	176.0	- 5	- 1	5	20.7	"	"	"
237	13.73	226	227	167	165	127	134	184.0	+ 1	- 3	3.1	20.9	"	"	"
269		Sight Camera finished run													
289	24.0	Inst. Camera finished run													

MISSION #3 Aug 7, '47   Run #6 Page #1   Sp(up) - 4 secs.

Frame	t_{corr}	T_e	R_e	T_d	R_d	P_{se}	P_{sd}	P_s	$[T]_{TLe}$	$[T]_{TLd}$	$[T]_{TL}$	Clock time	V_A	Accel.	Altitude
	secs	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Secs	Knots	g's	Feet
1			100		298.5							0.4	188	1.1	7250
5			98.5		298.5							0.6	"	"	"
9			98		298.5							0.8	"	"	"
13			98		298.5							1.1	"	"	"
UNCAGED 17	.00		101		299	0	0	0				1.3	"	"	"
21	.279		103		296.5	4	2	4.4				1.8	"	"	"
25	.559		107		292.5	8	6	10				1.9	"	"	"
29	.839		111		286.5	12	14	18				2.2	"	"	"
33	1.12		115.5		279.5	16.5	19	25.2				2.4	"	"	"
37	1.40		119		273.5	20	25	32				2.6	"	"	"
41	1.68		122		268.5	23	30	37.5				2.8	"	"	"
45	1.96	123.5	122	266	264	26	34.5	43	1.5	2	2.4	3.0	"	"	"
49	2.24	126	127	262	260.5	28	38	47	1	1.5	1.7	3.3	"	"	"
53	2.52	130	130	257.5	257.5	31	41.0	51	0	0	0	3.5	"	"	"
57	2.80	129.5	129.5	255	255	30.5	43.5	53	0	0	0	3.7	"	"	"
61	3.08	130	128.5	254	253	29.5	45.5	54	1.5	1.0	1.7	4.	"	"	"
65	3.35	131	128	252	250.5	29	48.6	56	3	1.5	3.3	4.2	"	"	"
69	3.64	132.5	127.5	249	246.5	28.5	52.	59	5	2.5	5.7	4.5	"	"	"
73	3.92	132.5	126.	245	243.5	27	55	61.5	6.5	1.5	6.9	4.8	"	"	"
77	4.19	130	124.5	242	241	25.5	57.5	63.	5.5	1	5.8	5.0	"	"	"
81	4.47	130	122	236.5	234.5	23	64	69	8	2	8.1	5.2	"	"	"
85	4.76	128.5	121	235	230.5	22	68	71.5	7.5	4.5	8.8	5.5	"	"	"
89	5.03	129	119.5	230	228	20.5	70.5	74	9.5	2.0	9.7	5.8	"	"	"
93	5.31	129	119.5	226	222	20.5	73.5	77	9.5	4.0	10.0	6.0	"	"	"
97	5.59	127.5	118	224	223.5	19	75	77.5	9.5	0.5	9.6	6.2	"	"	"
101	5.87	127	117.5	222	222	18.5	75	79	9.5	.0	9.5	6.5	"	"	"
105	6.15	127	118	220	220	19.	78.5	81	9.0	.0	9.	6.8	"	"	"
109	6.43	126	117	217	217.5	18	81	83.8	9.0	0.5	9.1	7.0	"	"	"
113	6.71	126	117	214	216	18	82.5	84.5	9.0	2.0	9.2	7.2	"	"	"
117	6.99	126	117	212	214.5	18	84	86	9.0	2.5	9.5	7.5	"	"	"
121	7.27	127	118	209	214	19	84.5	87	9.0	5.	10.4	7.8	"	"	"
125	7.55	127	119	208	214	20	84.5	87.3	8.0	6	10.	8.0	"	"	"
129	7.83	129	120.5	207	214.5	21.5	84	86.5	8.5	7.5	11.3	8.2	"	"	"
133	8.11	131	123.0	205	214	24	84.5	87.7	8	9	12.2	8.5	"	"	"
137	8.38	132	124.	203	213	25	85.5	89	8	10	12.9	8.8	"	"	"
141	8.67	132	125	201	210.5	26	88.0	91.8	7	9.5	11.8	9.0	"	"	"
145	8.95	132	126	197.5	207.5	27	91	95	6	10	11.7	9.2	"	"	"
149	9.23	133.5	127	194.	204	28	94.5	98.5	6.5	10	11.8	9.5	"	"	"
153	9.51	134	127.5	190.	200.5	28.5	98.0	102.0	6.5	10.5	[illegible]	[illegible]	"	"	"

MISSION #3 Aug. 7. '47 RUN #6 Page #2 Sp(up) - 4 secs.

157	9.78	135	128	188	200	29	98.5	102.5	7	12	13	10.	188	1.1	7250
161	10.07	136	128.5	186	199.5	29.5	99	103.3	7.5	13.5	14.8	10.2	"	"	"
165	10.35	136.5	129.5	186	200	30.5	98.5	103	7	14	15.8	10.5	"	"	"
169	10.63	137	129	188.5	200.5	30	98	102.5	8	16	18	10.8	"	"	"
173	10.91	136	128	185	200.5	29	98	102	8	15.5	17.5	11	"	"	"
177	11.19	134.5	126.5	183	200	27.5	98.5	102	8	15	16.9	11.2	"	"	"
181	11.48	134	126.5	185.5	200	27.5	98.5	102	7.5	14.5	16.4	11.5	"	"	"
185	11.74	134	125.	186.5	202	26	96.5	100	9	15.5	18	11.7	"	"	"
189	12.03	136	126	190	206	27	92.5	96.3	10	16.0	19	12.0	"	"	"
193	12.31	137	127	192	207.5	28	91	95	10	17.5	18.5	12.2	"	"	"
197	12.60	138	126.5	194	212	27.5	86.5	90.5	11.5	18	21.5	12.5	"	"	"
201	12.88	139	127	198	215.5	28	83	87.5	12	17.5	21	12.7	"	"	"
205	13.15	141	128	201.5	218.5	29	80	84.8	13	17	21.5	12.9	"	"	"
209	13.43	142	129.5	203.5	220	30.5	78.5	84.0	12.5	16.5	20.8	13.1	"	"	"
213	13.71	142	130.0	204	220	31	78.5	84.5	12	16	20	13.3	"	"	"
217	14.00	142	130	205	219	31	79.5	85.5	12	14	19.4	13.5	"	"	"
221	14.28	142	132	204.5	215	33	83.5	89.8	10	10.5	14.5	13.8	"	"	"
225	14.56	144	134	205	214	35	84.5	91.5	10	9	13.5	14.2	"	"	"
229	14.84	147	138	205.5	211	39	87.5	95.7	9	5.5	10.8	14.5	"	"	"
233	15.12	150	141	207	211	42	87.5	97.0	9	4.0	10	14.7	"	"	"
237	15.39	155	145	207.5	209	46	89.5	100.2	10	1.5	10.2	15.0	"	"	"
241	15.67	154	147	209.1	209	48	89.5	101.2	7	0	7	15.2	"	"	"
245	15.95	157	151	209	207.5	51	91	104.0	7	1.5	7.2	15.5	"	"	"
249	16.23	159	153	210	207.5	54	91	105.5	6	2.5	6.5	15.8	"	"	"
253	16.51	161	157	212	206	58	92.5	109.0	4	6.	7.2	16.0	"	"	"
257	16.79	165	162	216	202	63	96.5	115.2	3	8	8.3	16.2	"	"	"
261	17.07	170	169	211	200.5	70	98	120.	1	10.5	10.6	16.5	"	"	"
265	17.35	175	177	211.5	198.5	78	100	126	2	13.	13.1	16.5	"	"	"
269	17.63	181	185	212	197.5	86	101	132.3	4	14.5	15.	16.8	"	"	"
273	17.91	187	192	211	193.0	93	105.5	140.3	5	18	18.8	17.0	"	"	"
277	18.19	196	203	210	190	104	108.5	150.	7	20	21.2	17.3	"	"	"
281	18.47	206	212	210	186	118	112.5	162.3	11	24	26.5	17.6	"	"	"
285	18.75	217.5	233	210	183	134	115.5	176.0	15.5	27	31.4	17.9	"	"	"
293	Sight Camera		Finished												
297	Inst. camera		Finished									22.5			

21

MISSION #2 Run #3 $S_{p(wp)}$ - 6 secs.
Aug 7 Page #1

Frame	$t_{corr.}$	T_e	R_e	T_d	R_d	P_{se}	P_{sd}	P_s	$[I]_{TLe}$	$[I]_{TLd}$	$[I]_{TL}$	Clock Time	V_A	Accel.	Altitude
	Secs	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Secs	Knots	g's	Feet
1			101		299							5.5	175	1.25	1940
5			101		299							5.8	"	"	"
9			101		301							6.1	"	"	"
ENCAGED 13	.00		101		301							6.3	"	"	"
17	.26		101		303	0	-3	-3				6.6	"	"	"
21	.52		104		301	3	-1	3.2				6.8	"	"	"
25	.78		108		297	7	3	7.6				7.1	"	"	"
29	1.04		113		293	12	7	13.9				7.3	"	"	"
33	1.30		118		286	17	14	22.0				7.5	"	"	"
37	1.56		124		280	23	20	30.4				7.8	"	"	"
41	1.82		130		274	29	26	38.9				8.1	"	"	"
45	2.08		135		267	34	33	47.4				8.3	"	"	"
49	2.34		141		262	40	38	58.0				8.6	"	"	"
53	2.60		147		259	46	41	61.5				8.8	"	"	"
57	2.86		154		254	53	46	70.0				9.1	"	"	"
61	3.12		160		251	59	49	76.6				9.3	"	"	"
65	3.38		167		246	66	54	85.2				9.6	"	"	"
69	3.64		173		241	72	59	92.0				9.9	"	"	"
73	3.90		180		232	79	67	103.5				10.1	"	"	"
77	4.16		185		225	84	75	112.5				10.3	"	"	"
81	4.42	184	187	230	218	86	82	119.0	+3	-12	12.4	10.6	"	"	"
85	4.68	190	190	220	208	89	92	128.0	0	12	12.0	10.9	"	"	"
89	4.94	192	190	211	199	89	101	134.5	-2	12	12.2	11.2	"	"	"
93	5.20	194	191	205	192	90	108	140.5	-3	13	13.3	11.5	"	"	"
97	5.46	196	191	199	186	90	114	141.5	-5	13	13.9	11.9	"	"	"
101	5.72	198	191	195	182	90	118	148.2	7	13	14.8	12.3	"	"	"
105	5.98	198	189	193	181	88	119	148.0	9	12	15.0	12.6	"	"	"
109	6.24	198	187	190	180	86	120	147.5	11	10	14.8	12.9	"	"	"
113	6.50	197	184	188	179	83	121	146.6	13	9	15.8	13.0	"	"	1900
117	6.76	?	181	?	176	80	124	147.4	?	?	?	13.2	"	"	"
121	7.02	?	179	?	172	78	128	150.0	?	?	?	13.4	"	"	"
125	7.28	?	176	?	167	75	133	152.2	?	?	?	13.6	"	"	"
129	7.54	187	172	176	160	71	140	157.0	15	16	22.0	13.8	"	1.20	"
133	7.80	185	170	158	153	69	147	162.5	15	5	15.8	13.9	"	"	"
137	8.06	183	169	150	148	68	152	166.5	14	2	14.1	14.0	"	"	"
141	8.32	180	166	147	146	65	154	166.7	14	1	14.0	14.1	"	"	"
145	8.58	176	164	144	142	63	158	170.0	12	2	12.1	14.3	"	"	"
151	8.84	174	164	142	140	63	160	172.0	10	2	10.2	14.6	"	"	"
155	9.10	175	164	139	140	63	160	172.0	11	1	11.0	14.9	"	"	"

MISSION #2 — AUG. 7, '47 — RUN #3 — Page #2 — $S_{p(wp)}$ - 6 secs

	159	9.36	178	166	137	140	65	160	172.5	- 12	+ 3	12.3	15.1	175	1.2	1900
	163	9.62	181	169	133	137	68	163	176.5	12	4	12.6	15.3	"	"	"
	167	9.88	185	174	128	135	73	165	180.5	11	7	13.0	15.6	"	"	"
	171	10.14	190	178	124	134	77	166	183.2	12	10	15.6	15.8	"	"	"
	175	10.40	194	182	119	125	81	175	192.8	12	6	13.4	16.1	"	"	"
	179	sight bulb burned out.														
	347	sight camera Finished														
	371	inst. camera Finished										28.0				

MISSION #2 RUN 4 $J_{P(HP)} = 6$ SEC.
7 AUGUST, 1947 PAGE 1

FRAME	t_{corr}	T_e	R_e	T_d	R_d	P_{se}	P_{sd}	P_3	(I)TLe	(I)TLd	(I)TL	CLOCK TIME	V_A	ACC.	ALT.
—	SEC	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	SEC.	KNOTS	G'S	FEET
4												2.5			
5												2.8			
9												3.0			
13	0		102		297							3.3	175	1.2	2330
17	.26		103		298.5	.4	1.1	1.2				3.5			
21	.52		109		298.5	1.9	1.1	1.8				3.75			
25	.78		110.5		297.5	7.9	.1	7.9				4.0			
29	1.09	118	117.5	291	293	14.9	4.4	15.7	.5	-2	2.1	4.2			
33	1.3	123	127	289	288.5	24.4	8.9	25.9	-4	+.5	4.0	4.5			
37	1.56	131	136	284	283	33.4	14.4	36.4	-5	+1	5.1	4.75			
41	1.82	138.5	146.5	281	277	43.9	20.4	48.5	-8	4	9.0	4.95			
45	2.08	147	156	278	272	53.4	25.4	59	-9	6	10.8	5.2			
49	2.39	155.5	164	273	266	61.4	31.4	69	-8.5	7	11	5.45			
53	2.6	164	175	269	259	72.4	38.4	82	-11	10	15	5.7			
57	2.86	172	183	262	250	80.4	47.4	93.4	-11	12	16.3	5.95			
61	3.12	180	192	252	240	89.4	57.4	106.3	-12	12	17	6.2			
65	3.38	187	198	242	229	95.4	68.4	119.4	-11	13	17	6.45			
69	3.64	199	204	231	217.5	101.4	79.9	128.5	-10	13.5	17.5	6.7			
73	3.9	200	209	221	206	106.4	91.4	140	-9	15	17.4	7.0			
77	4.16	209	212	212	195.5	109.4	101.9	148.7	-8	16.5	18.4	7.25			
81	4.42	209	211	205	187.5	108.4	109.9	153.9	-7	17.5	18.9	7.5			
85	4.68	203	207.5	198	180	104.9	117.4	157	-4.5	18	18.6	7.75			
89	4.94	201	204	192	174	101.4	123.4	159.5	-3	18	18.3	8.0			
93	5.2	200	201	186	167.5	98.4	129.9	162.5	-1	18.5	18.6	8.25			
97	5.46	199.5	199.5	181	163	97.9	134.4	165.5	0	18	18	8.5			
101	5.72	198	197	176	158	94.4	139.4	168.5	+1	18	18	8.7			
105	5.98	198	195	170	153.5	92.4	143.9	171	3	16.5	16.8	9.0			
109	6.29	198	195	164	148.5	92.4	148.9	175	3	15.5	15.7	9.25			
113	6.5	198	194	158	145	91.4	152.4	177	4	13	13.5	9.5			
117	6.76	197	197	151.5	139	94.4	158.4	184	0	12.5	12.5	9.75			
300	FINAL	FRAME	SIGHT	CAMERA								22.0			
320	"	"	INST.	"											

MISSION # 2 AUGUST 6, 1947 RUN #6 PAGE 1 $S_{P(WP)}$ = 6 SEC.

FRAME	$t_{corr.}$	T_e	R_e	T_d	R_d	P_e	P_d	P_s	(I)TL_e	(I)TL_d	(I)TL	Clock Time	V_A	Accel.	ALT.
—	sec.	mils	mils	mils	mils	mils	mils	mils	mils	mils	mils	sec.	knots	g's	feet
1	—		160		239							3.5	205	1.2	8730
5	—		106		239							3.7			
9	—		106		239							3.9			
13	—		106		239							4.2			
17	—		106		239							4.4			
21	UNCAGED 0		106		238		1	1				4.7			
25	.224		106		238		1	1				4.9			
29	.448		106		235		4	4				5.2			
33	.673		102		230	4	9	10				5.4			
37	.896	107	104	228	225	2	14	15	3	3	4.2	5.6			
41	1.12	111	110	230	222	4	17	18	1	8	8.2	5.9			
45	1.35	111	111	230	218	5	21	22	0	12	12	6.1			
49	1.57	113	114	229	213	8	26	27.5	1	16	16	6.3			
53	1.79	114	116	229	209	10	30	32	2	20	20.1	6.6			
57	2.02	117	120	226	204	14	35	38	3	22	22.5	6.8			
61	2.24	120	124	223	199	18	40	44	4	24	24.5	7.1			
65	2.47	124	128	219	193	22	46	51	1	26	26	7.3			
69	2.69	123	130	215	187	24	52	57	7	28	28.8	7.7			
73	2.91	126	134	210	181	28	58	64	8	29	30.1	7.9			
77	3.14	129	137	205	175	31	64	71	8	30	31.2	8.2			
81	3.36	131	141	200	170	35	69	77	10	30	32	8.5			
85	3.58	134	144	195	165	38	74	83	10	30	32	8.7			
89	3.82	138	148	191	160	42	79	89.5	10	31	32.8	8.9			
93	4.03	140	151	187	156	45	83	94	11	31	33	9.2			
97	4.26	144	154	184	151	48	88	100	10	33	34.8	9.4			
101	4.48	146	159	182	147	53	92	106	13	35	37.5	9.6			
105	4.71	150	160	178	143	54	96	110	10	35	36.4	9.8			
109	4.93	150	162	175	138	56	101	115	12	37	39	10.1			
113	5.16	152	164	170	131	58	108	122	12	39	41	10.3			
117	5.38	153	165	167	127	59	112	126	12	40	42	10.6			
121	5.61	156	166	161	121	60	118	132.5	10	40	41.5	10.7			
125	5.83	160	169	155	116	63	123	138	9	39	40	11			
129	6.05	161	171	151	112	65	127	143	10	39	40.2	11.2			
133	6.27	161	171	147	109	65	130	145	10	38	39.4	11.4			
137	6.50	161	171	144	107	65	132	146.5	10	37	38.4	11.6			
141	6.72	162	170	141	106	64	133	147	8	35	36	11.8			
145	6.95	162	170	138	105	69	134	148.5	8	33	34	12.1			

MISSION #2 RUN #6 $\delta_{P(WP)}$ = 6 SEC.
AUGUST 6, 1947 PAGE 2

FRAME	$t_{corr.}$	T_e	R_e	T_d	R_d	P_{se}	P_{sd}	(I)TL_e	(I)TL_d	(I)TL	Clock Time	V_A	Accel.	ALT.	D_s
149	7.17	161	168	136	104	62	135	7	32	32.8	12.3	205	1.2	8730	148.5
153	7.40	161	168	133	103	62	136	7	30	30.8	12.6				149
157	7.62	162	168	129	100	62	139	6	29	29.7	12.8				152
161	7.85	163	168	124	96	64	143	5	28	28.4	13.1				155.5
165	8.07	165	170	117	91	65	148	5	26	26.4	13.3				161
169	8.29	167	171	112	87	67	152	4	25	25.4	13.6				165
173	8.52	168	173	108	86	67	153	5	22	22.3	13.8	212			166.5
177	8.74	169	173	108	87	68	152	4	21	21.3	14				165.5
181	8.97	170	174	108	90	68	149	4	18	18.3	14.3				163.5
185	9.19	171	174	108	91	71	148	3	17	17.3	14.5				162.5
189	9.41	174	177	104	90	74	149	3	14	14.2	14.8				164.5
193	9.64	177	180	99	87	74	152	3	12	12.1	15.1				168.5
197	9.86	180	180	94	84	75	155	0	10	10	15.3			8780	171
201	10.2	180	181	90	81	75	158	1	9	9	15.6				174.5
205	10.32	181	181	87	80	77	159	1	7	7	15.8	210			175
209	10.54	183	183	86	81	77	158	0	5	5	16				175
213	10.76	183	183	86	83	79	156	0	3	3	16.3				173
217	10.98	185	185	86	85	78	154	0	1	1	16.5				172.5
221	11.22	186	184	86	86	80	153	2	0	2	16.7				171
225	11.44	189	186	84	86	83	153	3	2	3.6	16.9				172
229	11.67	192	189	82	85	84	154	3	3	4.2	17.2				174.5
233	11.89	194	190	79	83	86	156	4	4	5.7	17.5				176.5
237	12.11	195	192	76	82	86	157	3	6	6.6	17.8				178
241	12.33	195	192	73	80	87	159	3	7	7.7	18.1				180
245	12.56	195	193	71	79	88	160	2	8	8.2	18.3				181.5
249	12.79	197	194	70	79	90	160	3	9	9.4	18.6				182
253	13.02	200	196	69	79	92	160	4	10	10.6	18.8				183.5
257	13.24	200	198	69	79	94	160	2	10	10.1	19.1				184
261	13.45	203	200	68	79	95	160	3	11	11.4	19.3				185
265	13.68	204	201	67	79	97	160	3	12	12.3	19.6				185.5
269	13.92	206	203	66	78	99	161	3	12	12.3	19.8				187.5
273	14.12	208	205	64	78	102	161	3	14	14.3	20				188.5
277	14.34	211	208	63	76	105	163	3	13	13.3	20.2				191.5
281	14.57	213	211	63	76	105	163	2	13	13.2	20.5				193.5
285	14.81	216	211	62	75	106	164	5	13	13.8	20.7				194
289	15.02	216	212	61	75	105	164	4	14	14.6	20.9				195
293	15.24	214	211	61	74	103	168	3	13	13.3	21.2				196
297	15.49	213	209	60	73	100	166	4	13	13.5	21.4				195
301	15.70	214	206	61	73	100	166	8	12	14.5	21.6				193.5
	SEC.	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	SEC.	KNOTS	G's	FEET	MILS

MISSION #[illegible] [illegible] [illegible]
AUGUST 6, 1947 [illegible] [illegible]

$\Delta_{F(WD)}$ = 6 SEC

FRAME	t_{corr}	T_e	R_c	T_c	[illegible]	[illegible]	[illegible]	[illegible]	D_s	$(I)TL_c$	$(I)TL_d$	$(I)TL$	Clock Time	V_A	Accel.	ALT.
—	SEC.	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	SEC.	KNOTS	G'S.	FEET
305	15.92	215	208	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	10	12.1	21.8	210	1.2	8780
309	16.15	216	206	[illegible]	[illegible]	16	[illegible]	[illegible]	[illegible]	8	10	12.8	22.1			
313	16.15	215	209	68	[illegible]	[illegible]	[illegible]	62	190	9	9	12.5	22.3			
317	16.38	213	202	[illegible]	7	9	[illegible]	[illegible]	[illegible]	3	7	11.2	22.6			
321	16.59	212	201	[illegible]	[illegible]	[illegible]	16	153	185	10	6	11.1	22.8			
325	16.82	211	200	[illegible]	[illegible]	[illegible]	15	153	183.5	10	6	11.7	23.1			
329	17.09	208	199	83	[illegible]	[illegible]	10	[illegible]	182	8	1	8.1	23.3			
333	17.26	207	199	[illegible]	[illegible]	[illegible]	13	58	[illegible]	8	3	8.7	23.5			
337	17.5	207	203	[illegible]	[illegible]	[illegible]	13	160	[illegible]	3	5	9.5	23.8			
341	17.72	209	201	82	[illegible]	9	15	165	190.5	6	8	10	24.1			
375	SIGHT	CAMERA AT END OF RUN														
350	INST.	" "											24.5	FINAL.		

MISSION #3 RUN #5
AUGUST 7, 1947 PAGE 1 $S_{P(WP)}$ = 6 SEC

FRAME	t corr	Te	Re	Td	Rd	Pse	Psd	Ps	(I)TLe	(I)TLd	(I)TL	Clock Time	Va	Accel.	ALT.
—	SEC	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	SEC.	KNOTS	G's	FEET
1			98		299							9.75	186	1.2	7050
5	UNCAGED 0		98		299							9.95			
9	.25		99		298	1	1	1.4				10.15			
13	.508		100		297	2	2	2.8				10.35			
17	.762		101		295	3	4	5.0				10.55			
21	1.016		102		294	5	5	7.1				10.9			
25	1.27		104		291	6	8	10				11.1			
29	1.52	109	107	284	288	9	11	14	-2	4	4.4	11.3			
33	1.78	113	111	283	286	13	13	18.4	-2	3	3.5	11.6			
37	2.03	115	115	283	283	17	16	23.3	0	0	0	11.9			
41	2.28	120	120	278	280	22	19	29	0	2	2	12.1			
45	2.54	125	125	274	275	27	24	36.2	0	1	1	12.3			
49	2.79	130	130	270	271	32	28	42.5	0	1	1	12.5			
53	3.05	135	135	267	267	37	32	48.9	0	0	0	12.75			
57	3.30	143	143	261	261	45	38	59	0	0	0	13			
61	3.55	148	148	257	257	50	42	65.4	0	0	0	13.2			
65	3.81	152	152	251	251	54	48	72.3	0	0	0	13.4			
69	4.06	158	156	247	246	58	53	78.7	-2	-1	2.1	13.7			
73	4.32	162	159	243	240	61	59	85.3	-3	-3	4.2	14			
77	4.57	162	160	238	234	62	65	90	-2	-4	4.4	14.2			
81	4.82	164	160	233	229	62	70	93.5	+2	-4	4.4	14.5			
85	5.08	162	160	229	224	62	75	97.4	2	-5	5.3	14.8			
89	5.33	163	154	223	~~224~~ 218	56	81	98.5	9	-5	10.3	15			
93	5.54	161	150	219	214	52	85	99.6	11	-5	12	15.2			
97	5.84	158	146	214	208	48	91	102.1	12	-6	13.5	15.4			
101	6.10	156	143	210	205	45	94	104	13	-5	14	15.7			
105	6.35	148	138	204	199	40	100	107.4	10	-5	11.4	15.9			
109	6.60	148	135	204	197	37	102	108.3	13	-7	14.8	16.2			
113	6.86		130		193	32	106	110	-	-	-	16.4			
117	7.12		127		191	29	108	111.8	-	-	-	16.7			
121	7.37		124		188	26	111	113.6	-	-	-	16.9			
125	7.62		123		185	25	113	115.3	-	-	-	17.2			
129	7.87		123		183	25	116	118.5	-	-	-	17.4			
133	8.12	138	123	184	180	25	119	121.3	15	-4	15.6	17.8			
137	8.37	138	124	179	176	26	123	125	14	3	14.4	18			
141	8.64	138	125	175	174	27	125	127.5	13	1	13.1	18.2			
145	8.89	142	130	172	172	32	127	130.8	12	0	12	18.5			
149	9.14	145	132	169	171	34	128	132	13	2	13.2	18.8			

MISSION # 3 RUN # 5
AUGUST 7, 1947 PAGE 2

$S_{P(WP)}$ = 6 SEC.

FRAME	t_{corr}	T_e	R_e	T_d	R_d	P_{se}	P_{sd}	P_s	(I)TL_e	(I)TL_d	(I)TL	Clock Time	V_a	Accel.	ALT.
–	SEC.	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	MILS	SEC	KNOTS	G's	FEET
153	9.40	146	136	167	169	38	130	135	10	2	10.2	19	185	1.2	7050
157	9.66	148	141	165	167	43	132	138.6	7	2	7.2	19.1			
161	9.91	151	144	162	166	46	133	140.4	7	4	8.1	19.4			
165	10.15	155	150	160	164	52	135	144.8	5	4	6.5	19.6			
169	10.42	160	155	155	160	57	139	150	5	5	7.1	19.9			
173	10.67	165	160	153	158	62	141	154	5	5	7.1	20.1			
177	10.91	170	168	146	153	70	146	161.5	-2	7	7.2	20.3			
181	11.18	175	175	143	149	77	150	168.5	0	6	6	20.5			
185	11.43	183	182	140	146	84	153	174	-1	6	6.1	20.8			
189	11.68	186	186	138	146	88	163	176.8	0	8	8	21			
193	11.93	187	187	136	144	89	155	178	0	8	8	21.2			
197	12.19	186	186	135	145	88	154	176.7	0	10	10	21.5			
201	12.44	189	189	134	144	91	155	179.3	0	10	10	21.7			
205	12.71	193	186	135	142	88	157	179.4	-7	7	10	21.9			
209	12.95	195	188	137	146	90	153	177	7	9	11.4	22.2			
213	13.21	197	190	138	145	92	154	178.7	7	7	10	22.5			
217	13.48	200	190	140	146	92	153	177.8	10	6	11.5	22.75			
221	13.72	200	190	140	146	92	153	177.8	10	6	11.5	22.9			
225	13.98	201	188	138	144	90	155	179	13	6	14.3	23.1			
229	14.22	200	185	140	145	87	154	176.4	15	5	15.8	23.3			
233	14.48	201	184	139	143	86	156	177.8	17	4	17.5	23.6			
237	14.73	198	186	139	142	88	157	179.3	12	3	12.3	23.9			
241															
277	LAST	FRAME	SIGHT CAMERA												
295	"	"	INST. "									27.4			

Thesis 7907
H7 Holmberg
An investigation of the dynamic characteristics of a two-gyro computing system for aerodynamics-lead pursuit courses.